US009091825B2

(12) **United States Patent**
Takahashi et al.

(10) **Patent No.: US 9,091,825 B2**
(45) **Date of Patent: Jul. 28, 2015**

(54) **OPTICAL FIBER CONNECTOR, OPTICAL FIBER CONNECTOR ASSEMBLING METHOD, FUSION-SPLICED PORTION REINFORCING METHOD, PIN CLAMP, CAP-ATTACHED OPTICAL FIBER CONNECTOR, OPTICAL FIBER CONNECTOR CAP, OPTICAL FIBER CONNECTOR ASSEMBLING TOOL, AND OPTICAL FIBER CONNECTOR ASSEMBLING SET**

(71) Applicant: **FUJIKURA LTD.**, Kohtoh-ku, Tokyo (JP)

(72) Inventors: **Shigeo Takahashi**, Sakura (JP); **Kazuhiro Takizawa**, Sakura (JP)

(73) Assignee: **FUJIKURA LTD.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/108,646**

(22) Filed: **Dec. 17, 2013**

(65) **Prior Publication Data**

US 2014/0105548 A1 Apr. 17, 2014

Related U.S. Application Data

(60) Division of application No. 13/548,927, filed on Jul. 13, 2012, now Pat. No. 8,678,670, which is a continuation of application No. PCT/JP2011/050560, filed on Jan. 14, 2011.

(30) **Foreign Application Priority Data**

Jan. 14, 2010 (JP) 2010-006290
Jan. 14, 2010 (JP) 2010-006292
Jan. 14, 2010 (JP) 2010-006331

(51) **Int. Cl.**

G02B 6/36 (2006.01)
G02B 6/00 (2006.01)
G02B 6/38 (2006.01)
G02B 6/255 (2006.01)

(52) **U.S. Cl.**

CPC ***G02B 6/387*** (2013.01); ***G02B 6/3833*** (2013.01); ***G02B 6/3846*** (2013.01);
(Continued)

(58) **Field of Classification Search**

CPC G02B 6/387; G02B 6/3846; G02B 6/3882
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,748,819 A 5/1998 Szentesi et al.
6,439,780 B1 * 8/2002 Mudd et al. 385/83

FOREIGN PATENT DOCUMENTS

CN 2582016 Y 10/2003
EP 0 800 100 A1 10/1997

(Continued)

OTHER PUBLICATIONS

"F13 Type MULTI_CORE Optical Fiber Connector C 5982", JIS Handbook 8 Electronic Test Methods and Optoelectronics Edition, published by Japanese Standards Association, Apr. 24, 1998.

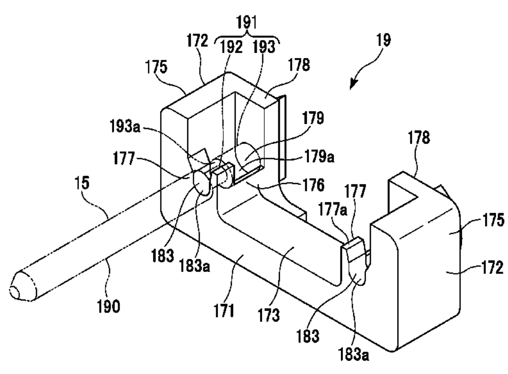
(Continued)

Primary Examiner — Omar R Rojas
(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

An optical fiber connector includes a ferrule, an inserted optical fiber, an external optical fiber, and a pair of reinforcing members that pinches and reinforces a fusion-spliced portion of the other end portion of the inserted optical fiber and the front end portion of the external optical fiber. The reinforcing members include adhesion layer on the inner surface thereof which comes in contact with the other end portion of the inserted optical fiber and the front end portion of the external optical fiber. The adhesion layer is depressed at the position where the inserted optical fiber and the external optical fiber come in contact with each other so as to closely adhere to the outer circumferential surfaces of the optical fibers in the fusion-spliced portion.

8 Claims, 50 Drawing Sheets



(52) **U.S. Cl.**
CPC ***G02B 6/3849*** (2013.01); *G02B 6/2558* (2013.01); *G02B 6/3898* (2013.01); *Y10T 29/4989* (2015.01); *Y10T 29/49908* (2015.01); *Y10T 156/10* (2015.01)

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

JP	58-123412	U	8/1983
JP	59-071010	A	4/1984
JP	60-051807	A	3/1985
JP	06-034845	A	2/1994
JP	09-105837	A	4/1997
JP	10-319275	A	12/1998
JP	2001-235656	A	8/2001
JP	2002-082257	A	3/2002
JP	2002-196189	A	7/2002
JP	2006-227560	A	8/2006
JP	2008-065315	A	3/2008

OTHER PUBLICATIONS

Japanese Office Action issued by the Japanese Patent Office in Japanese Patent Application No. 2013-008478 dated Sep. 10, 2013.

Chinese Office Action issued by the Chinese Patent Office in Chinese Patent Application No. 201180006107.1 dated Dec. 25, 2013.

* cited by examiner

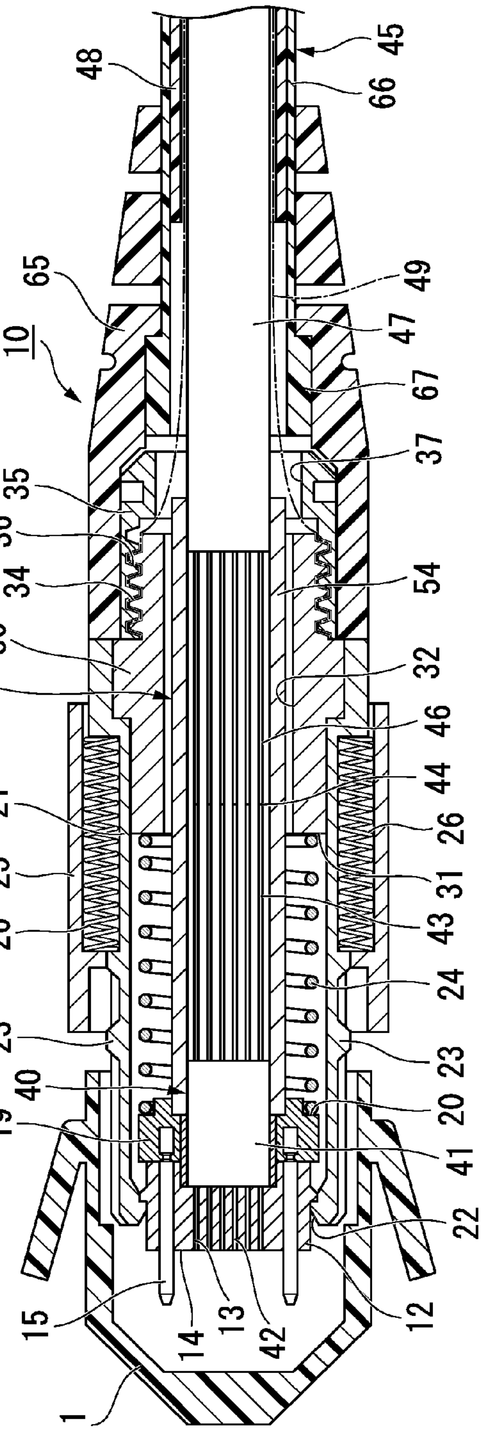

10
11
12
13
14
15
19
20
21
22
23
24
25
26
30
31
32
34
35
36
37
40
41
42
43
44
45
46
47
48
49
50
54
65
66
67

FIG. 1A

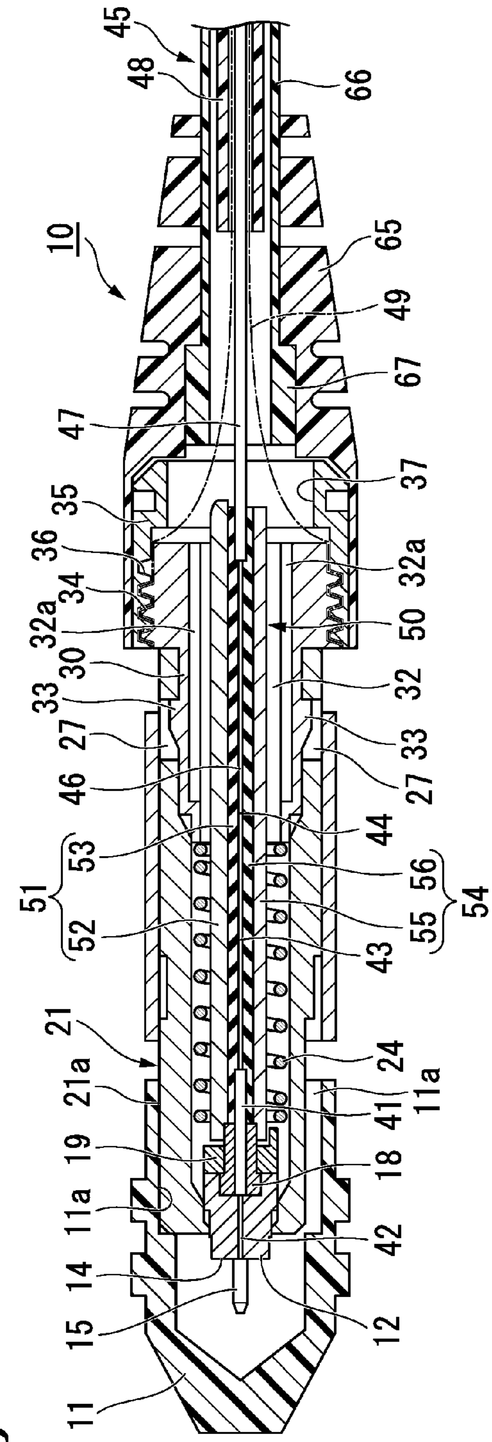

10
11
11a
12
14
15
18
19
21
21a
24
27
30
32
32a
33
34
35
36
37
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
65
66
67

FIG. 1B

FIG. 2A

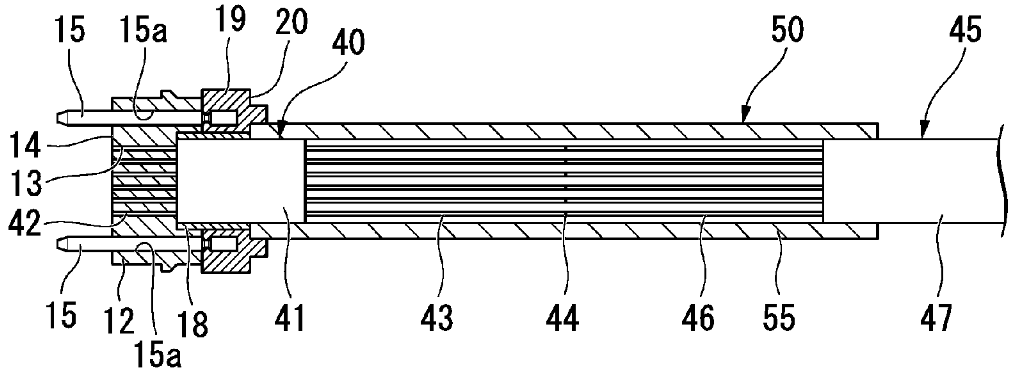


FIG. 2B

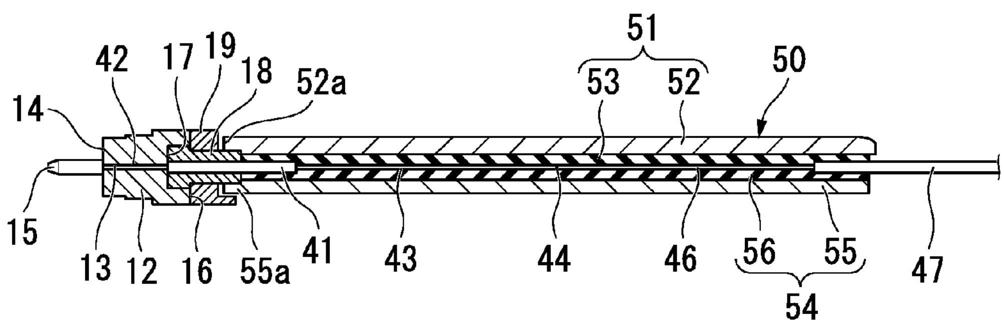


FIG. 3

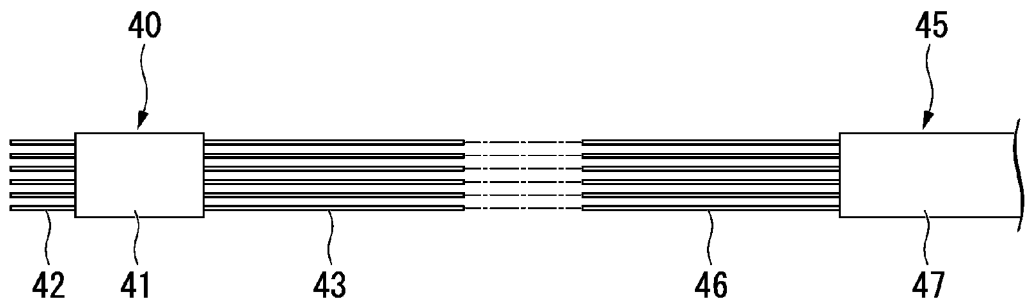


FIG. 4A

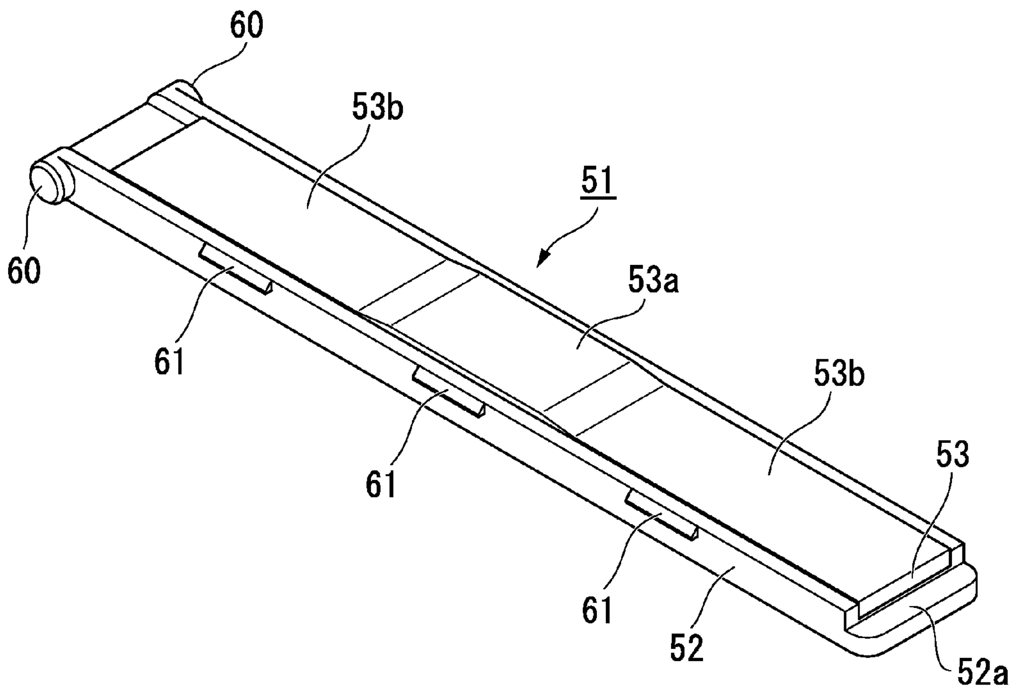

60
53b
51
60
53a
61
53b
61
53
61
52
52a

FIG. 4B

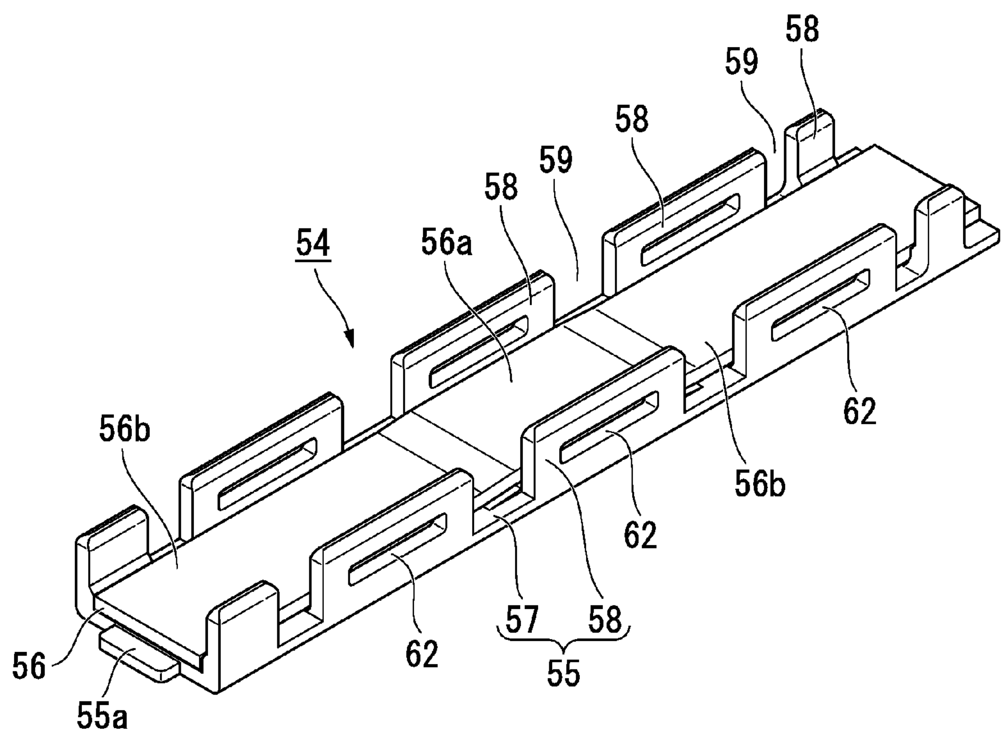

58
59
58
59
58
54
56a
56b
62
56b
62
57
58
55
56
62
55a

FIG. 5

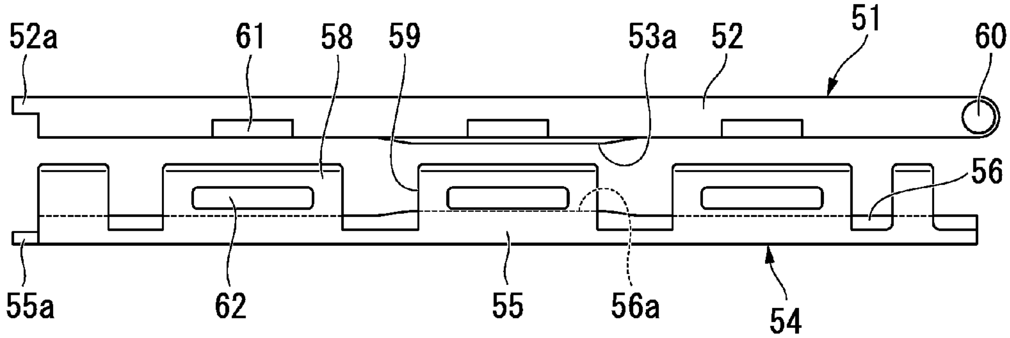


FIG. 6

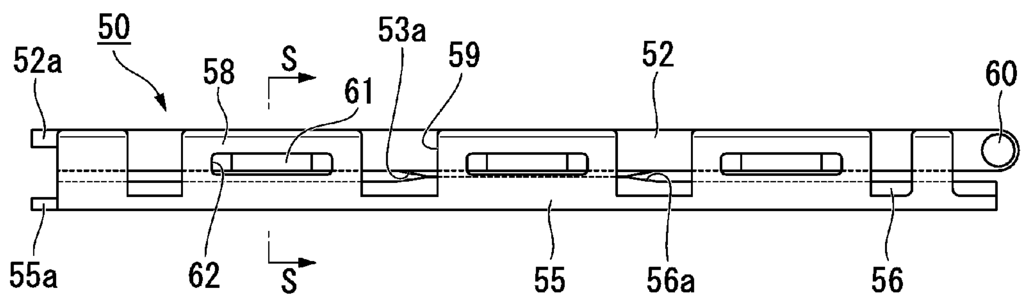


FIG. 7

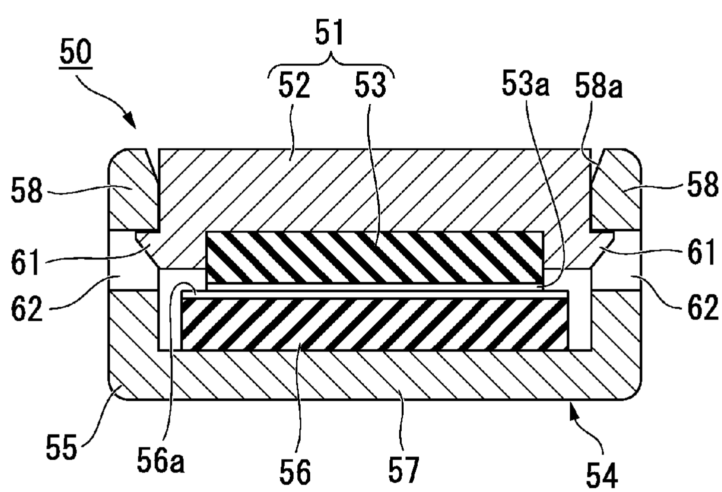


FIG. 8

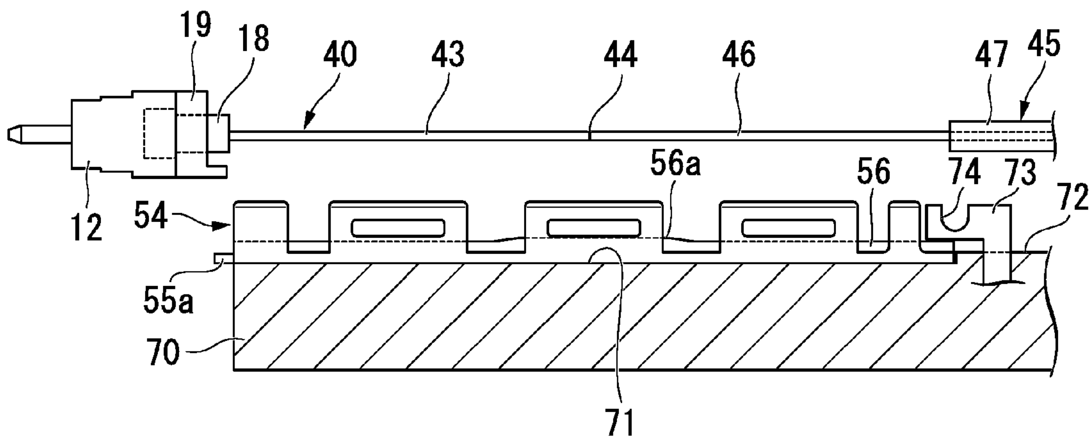

19
18
40
43
44
46
47
45
12
56a
56
74
73
72
54
55a
70
71

FIG. 9

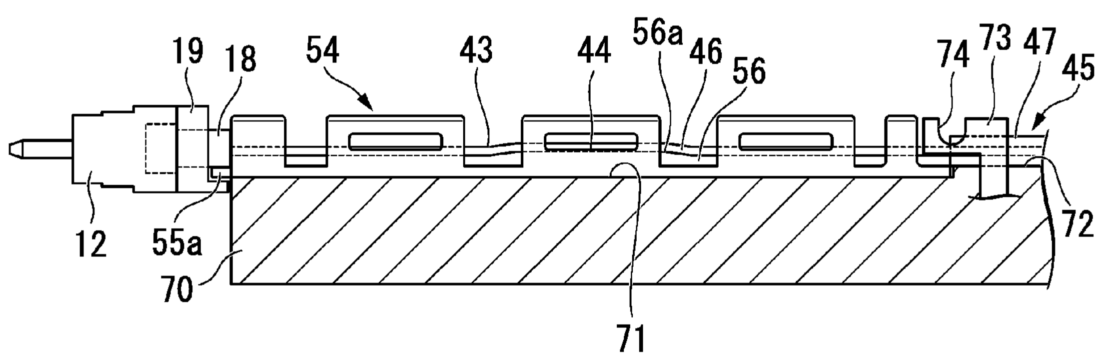

19
18
54
43
44
56a
46
56
74
73
47
45
12
55a
70
71
72

FIG. 10

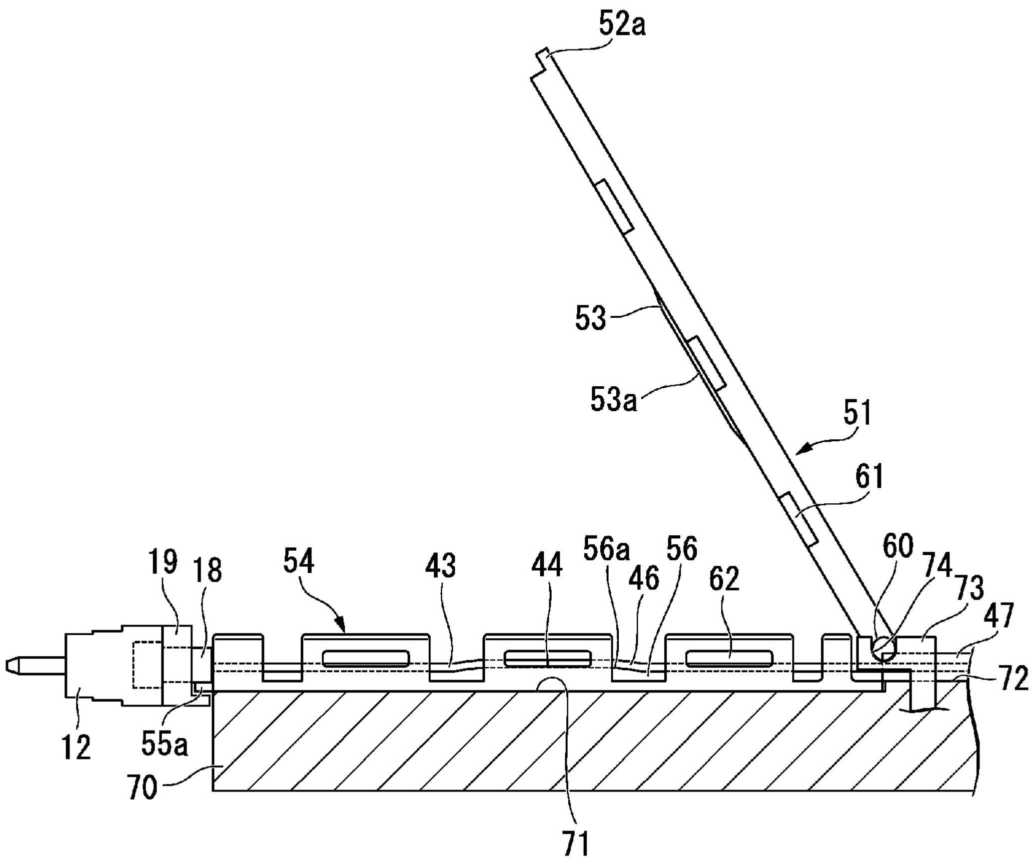

52a
53
53a
51
61
19
18
54
43
44
56a
46
56
62
60
74
73
47
72
12
55a
70
71

FIG. 11

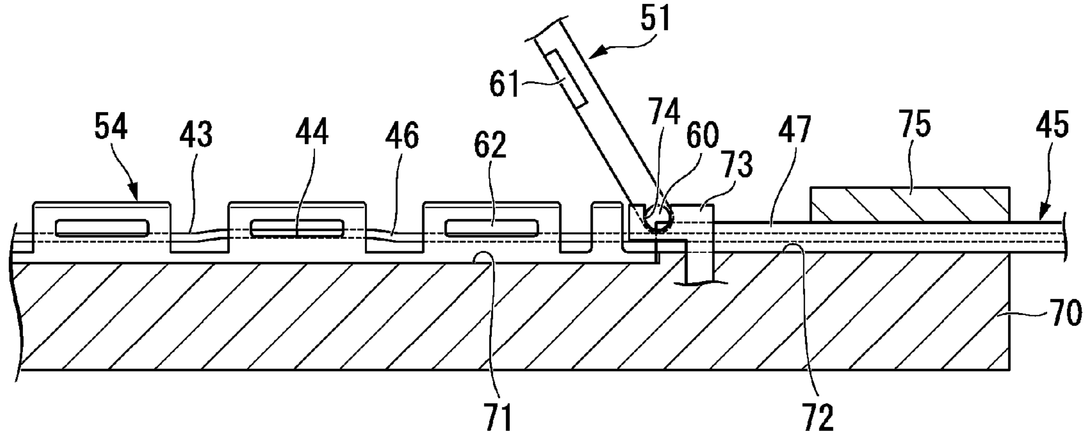


FIG. 12

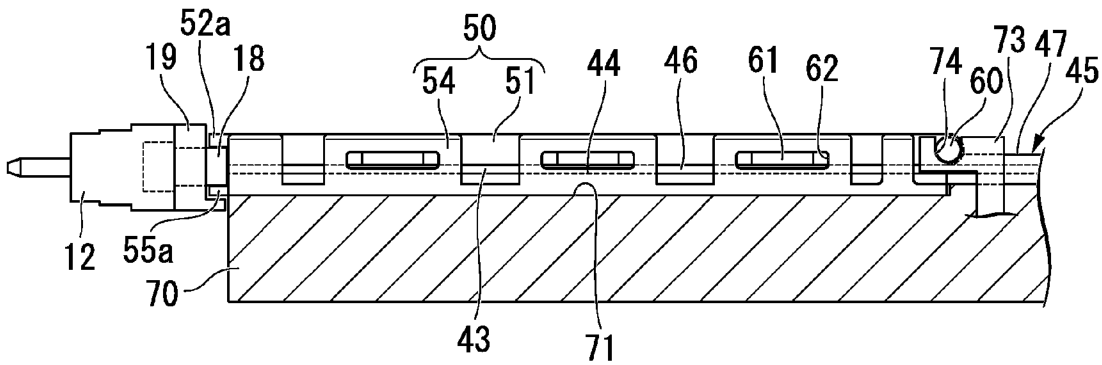
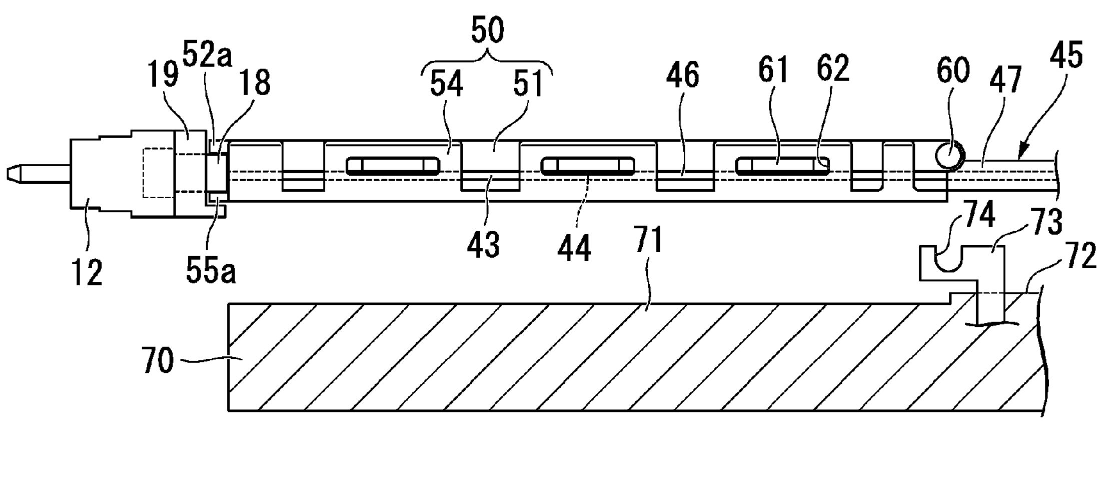


FIG. 13



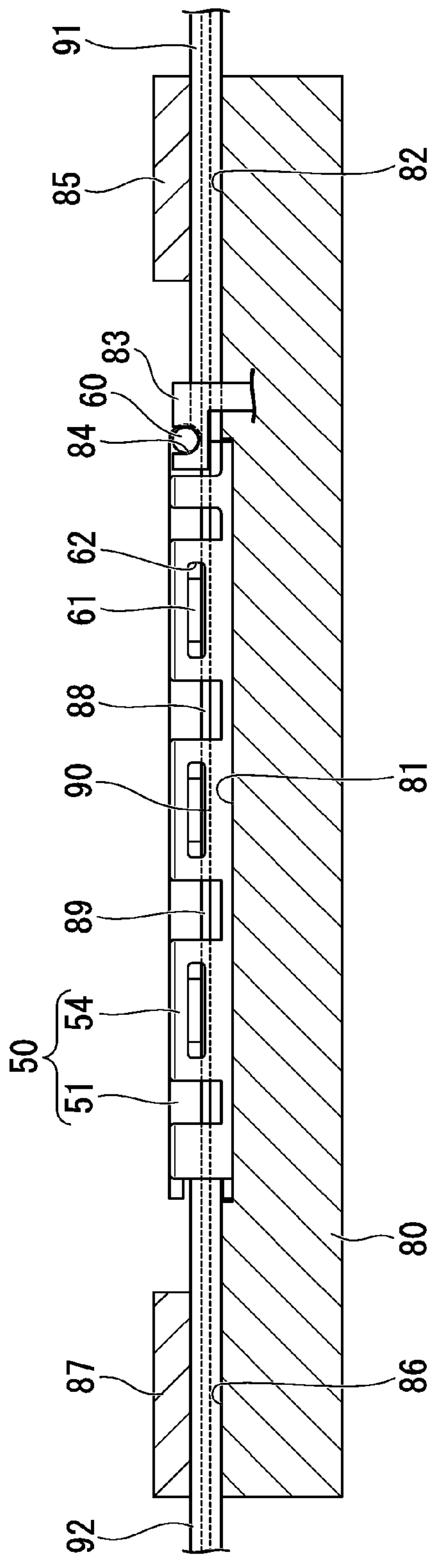


FIG. 14

FIG. 15

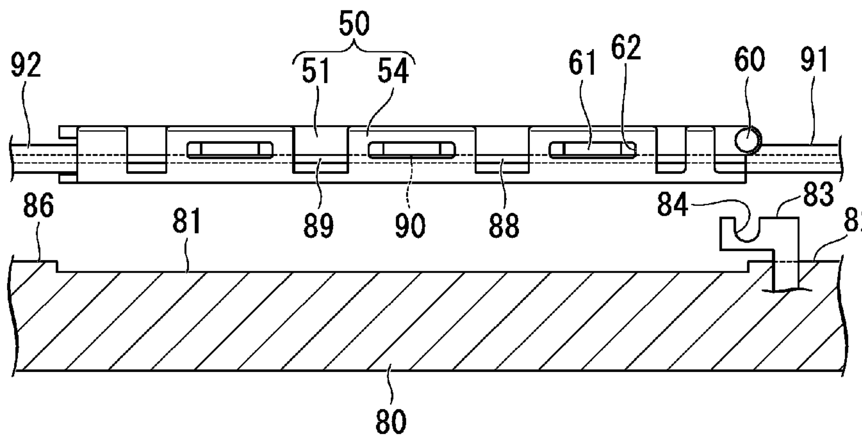
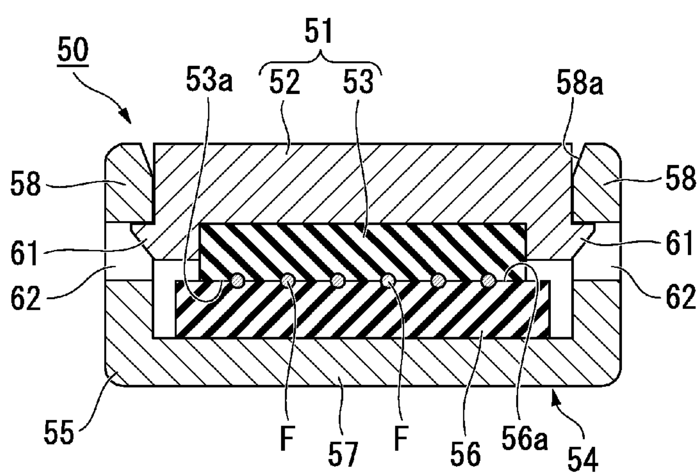

50
92
51
54
61
62
60
91
89
90
88
84
83
82
86
81
80

FIG. 16


51
50
53a
52
53
58a
58
58
61
61
62
62
55
F
57
F
56
56a
54

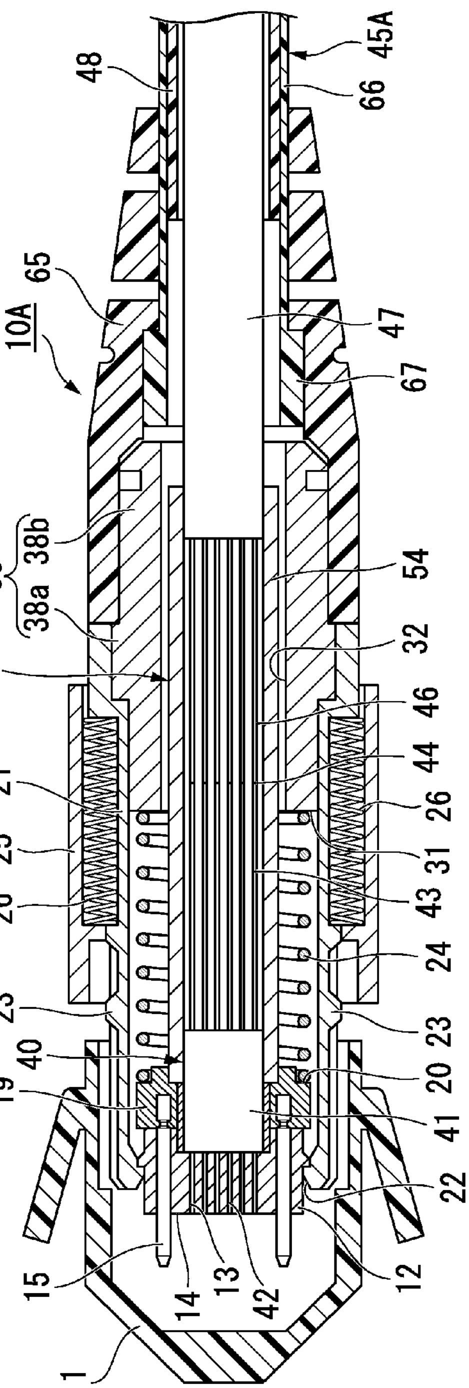


FIG. 17A

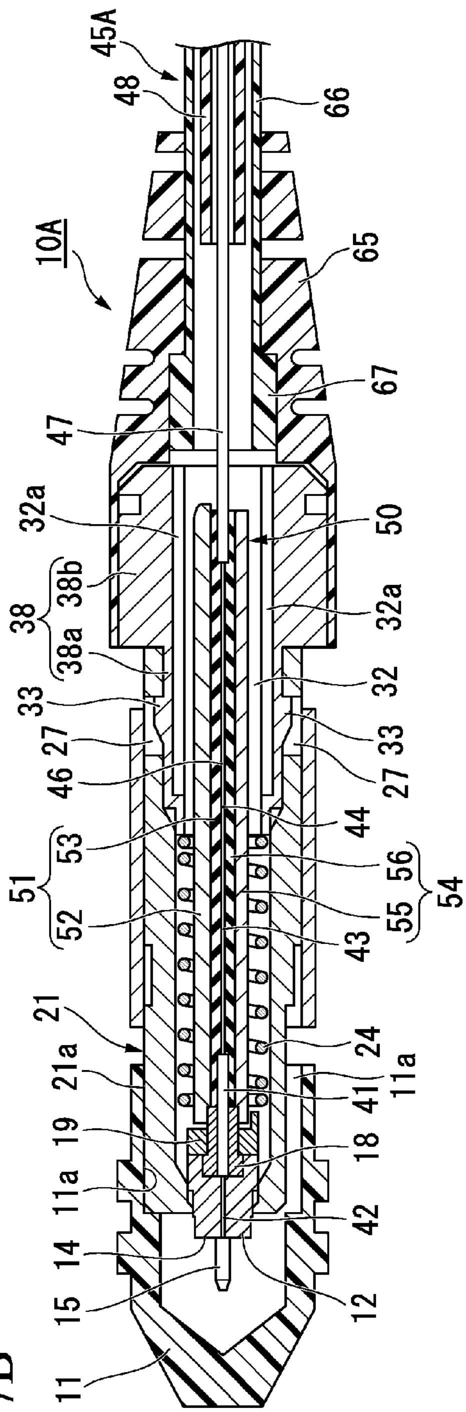


FIG. 17B

FIG. 18

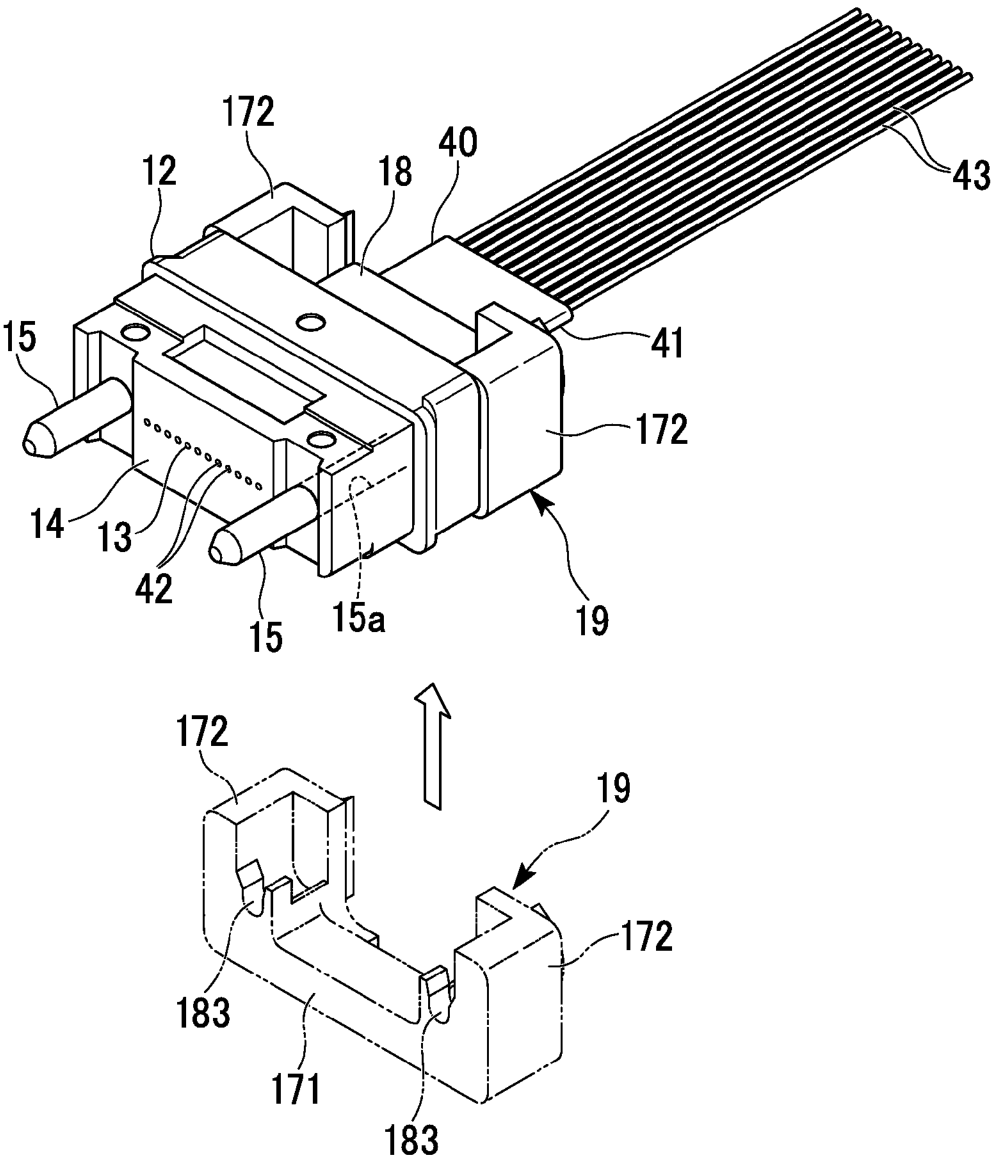


FIG. 19

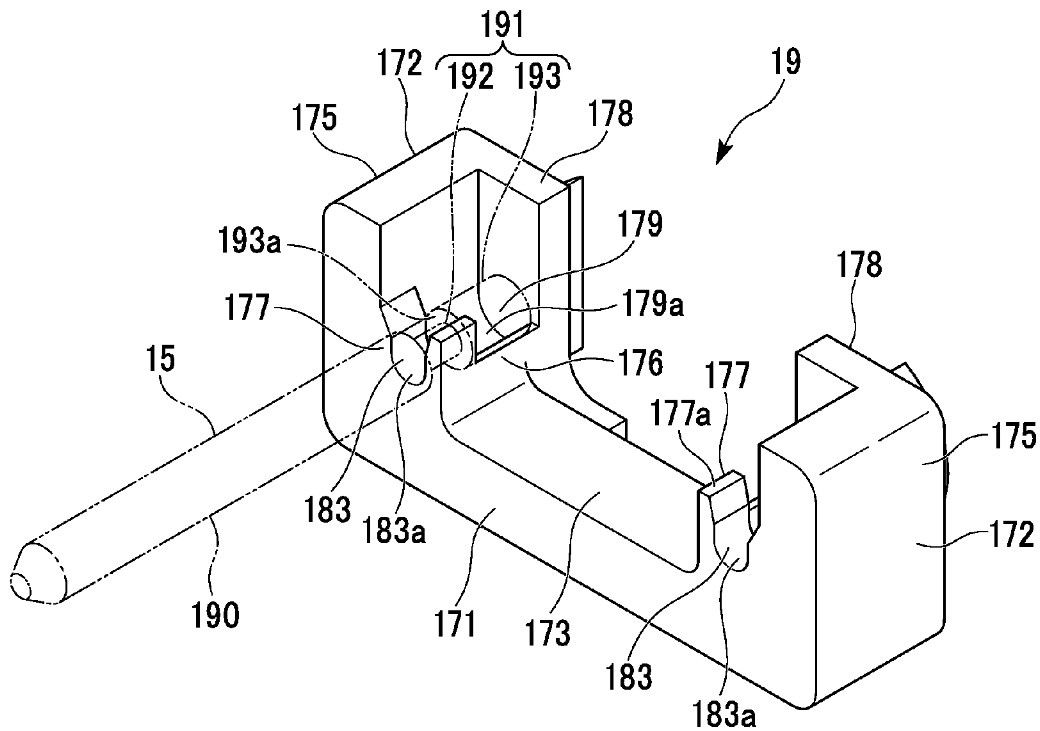

191
172
192
193
19
175
178
193a
179
177
179a
178
15
176
177
177a
175
183
183a
172
190
171
173
183
183a

FIG. 20

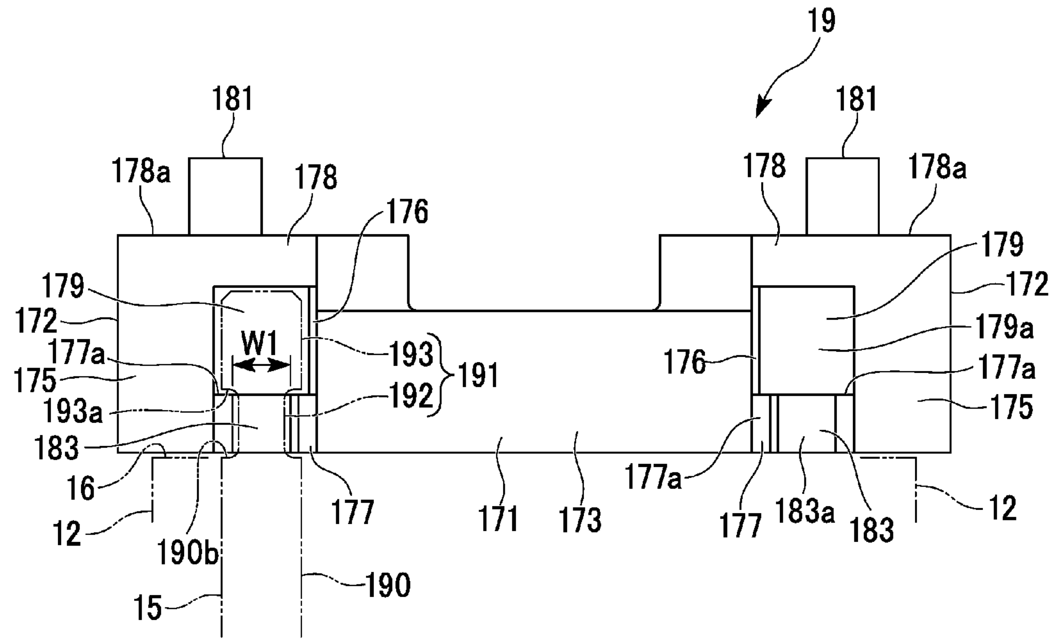

19
181
178a
178
176
181
178
178a
179
172
177a
175
193a
183
16
12
190b
15
W1
193
192
191
177
171
173
190
176
179
172
179a
177a
175
177a
177
183a
183
12

FIG. 21

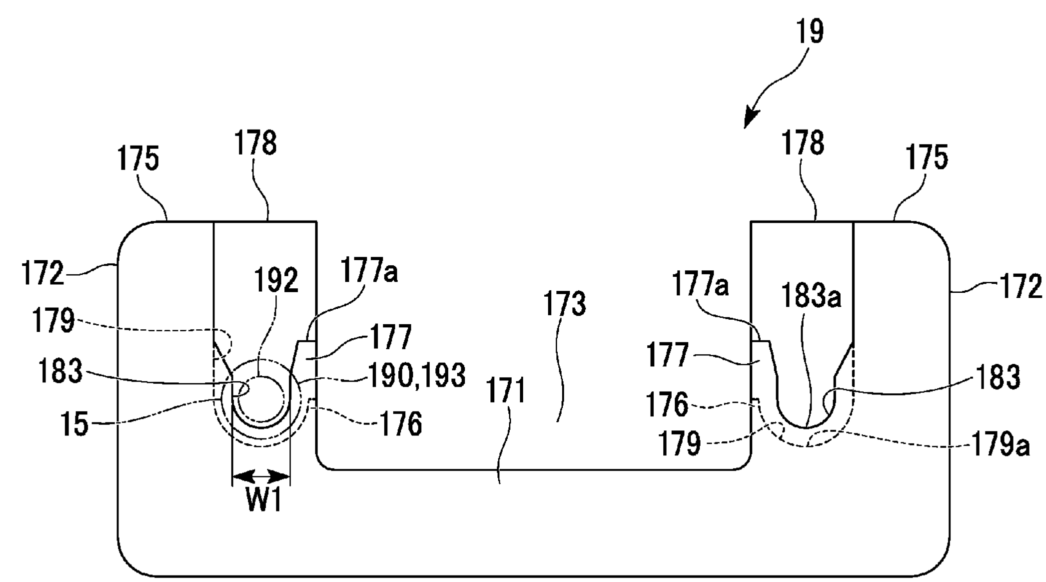
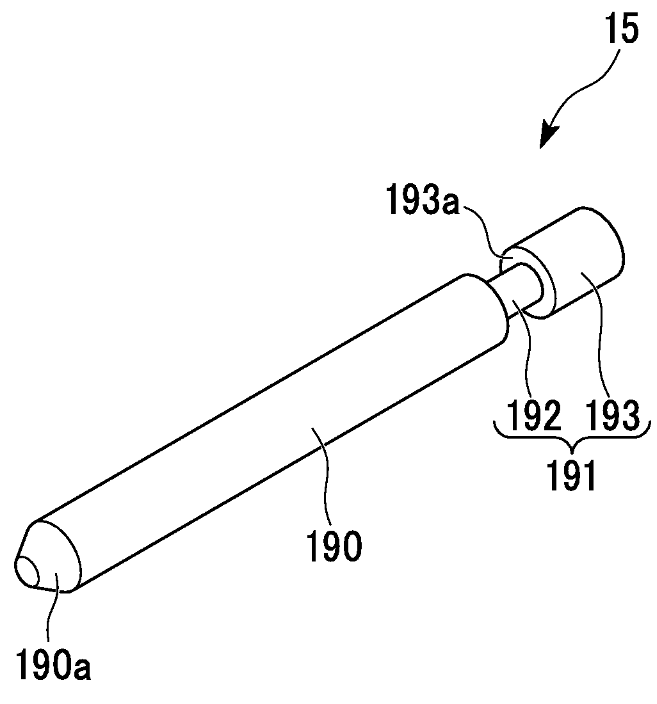

19
175
178
172
179
183
15
192
177a
177
190,193
176
W1
173
171
178
175
177a
183a
172
177
176
179
183
179a

FIG. 22



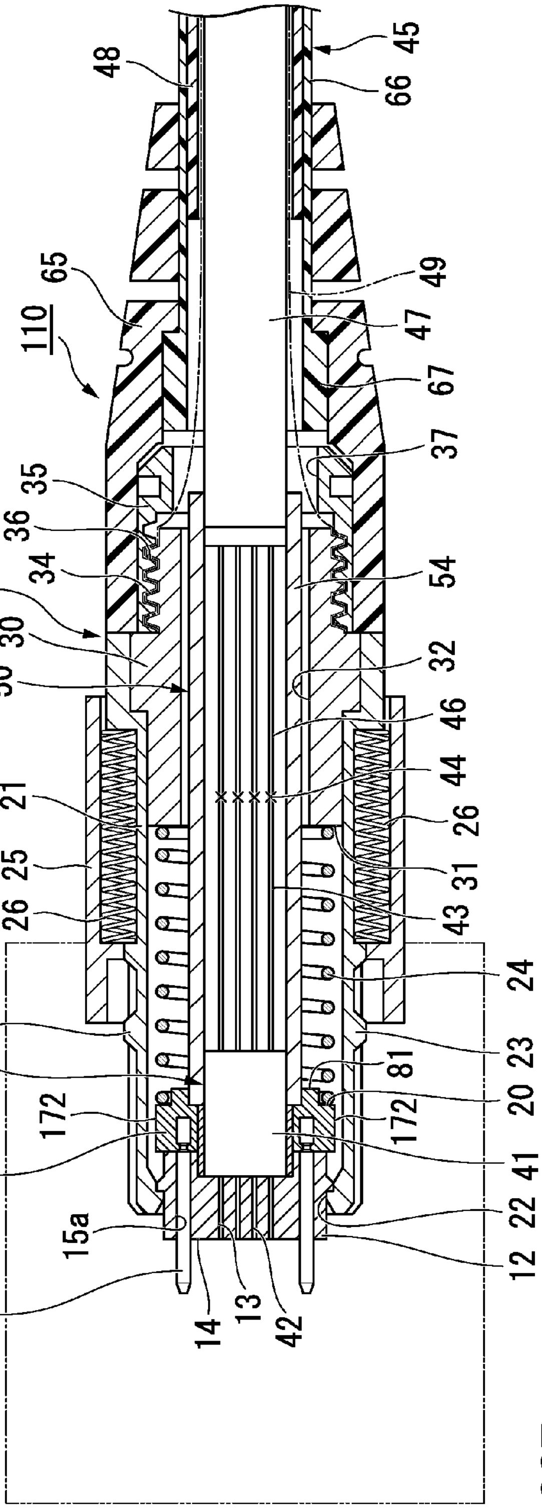


FIG. 23A

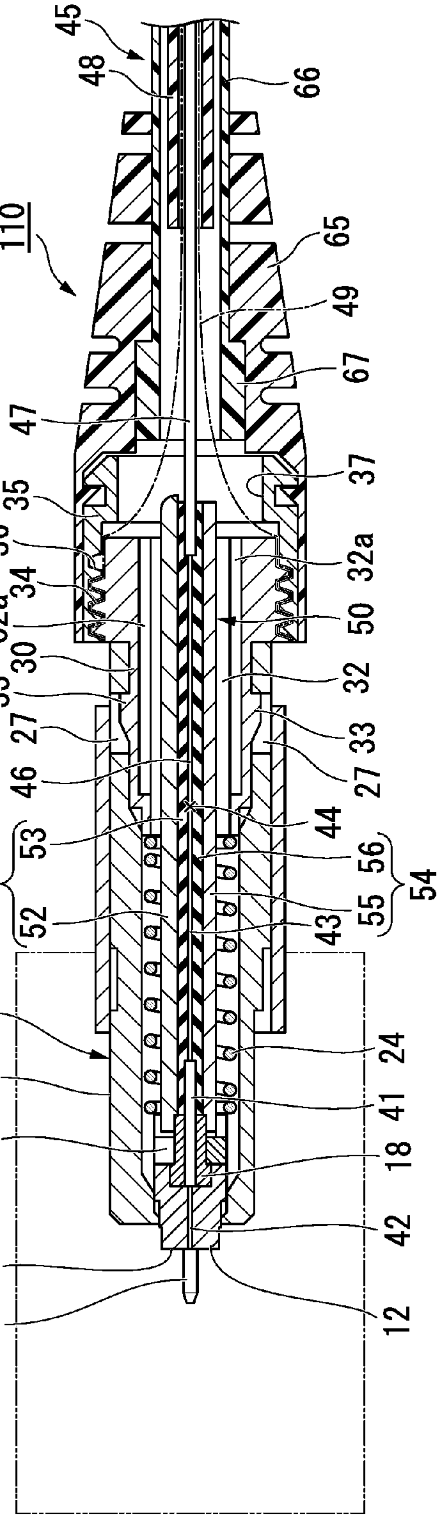


FIG. 23B

FIG. 24A

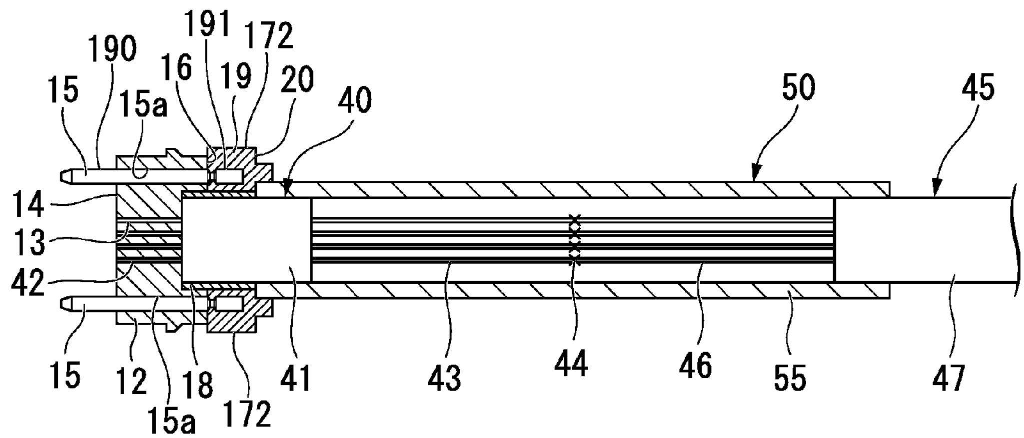


FIG. 24B

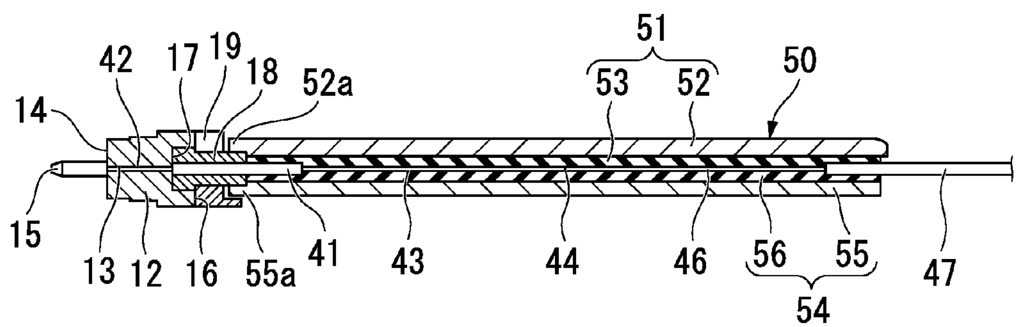


FIG. 25

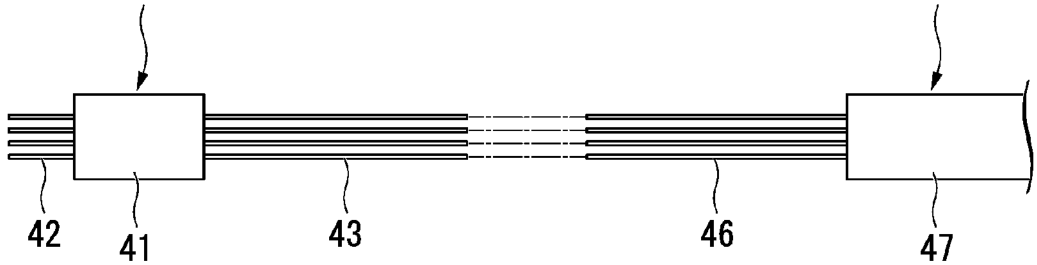


FIG. 26

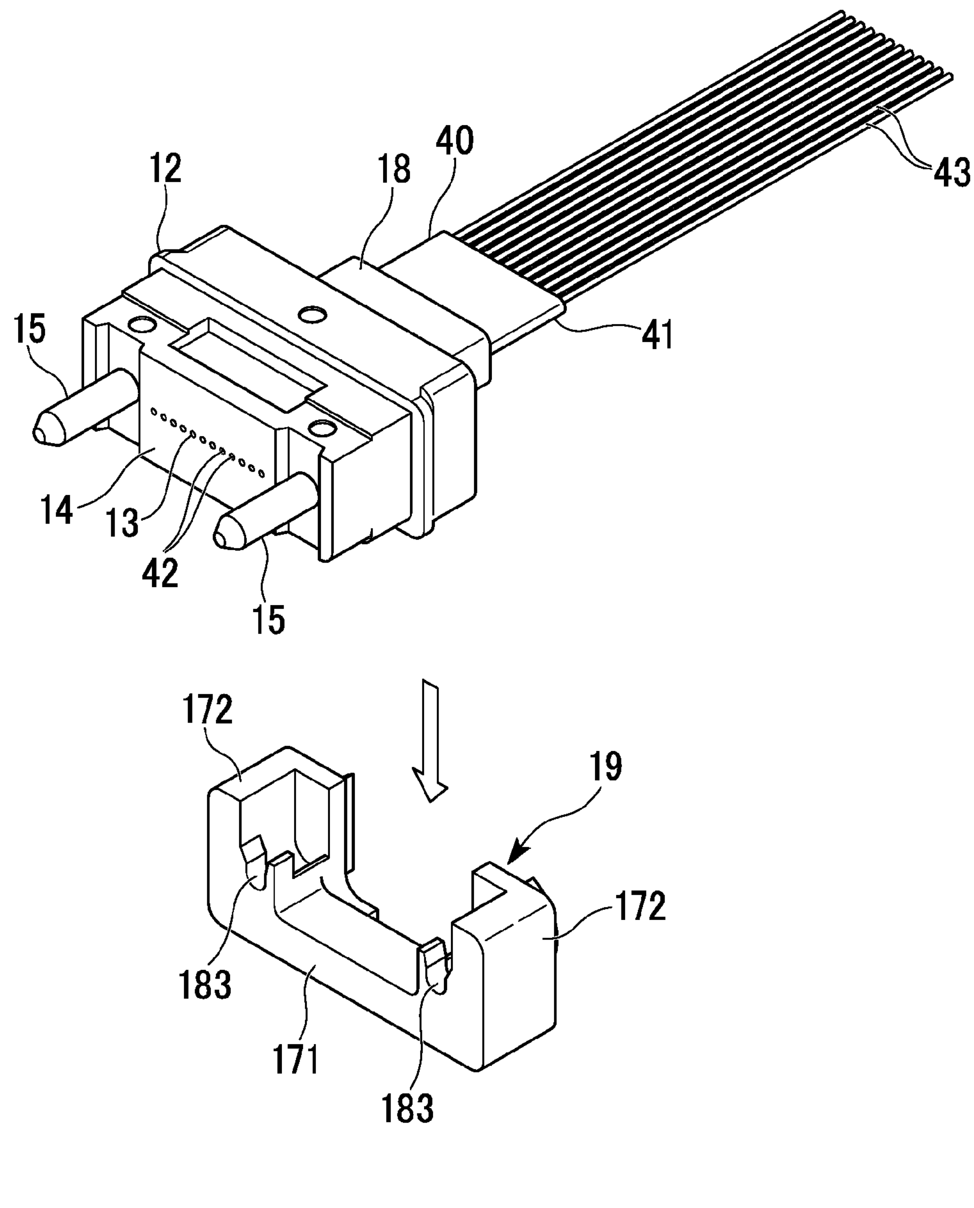


FIG. 27

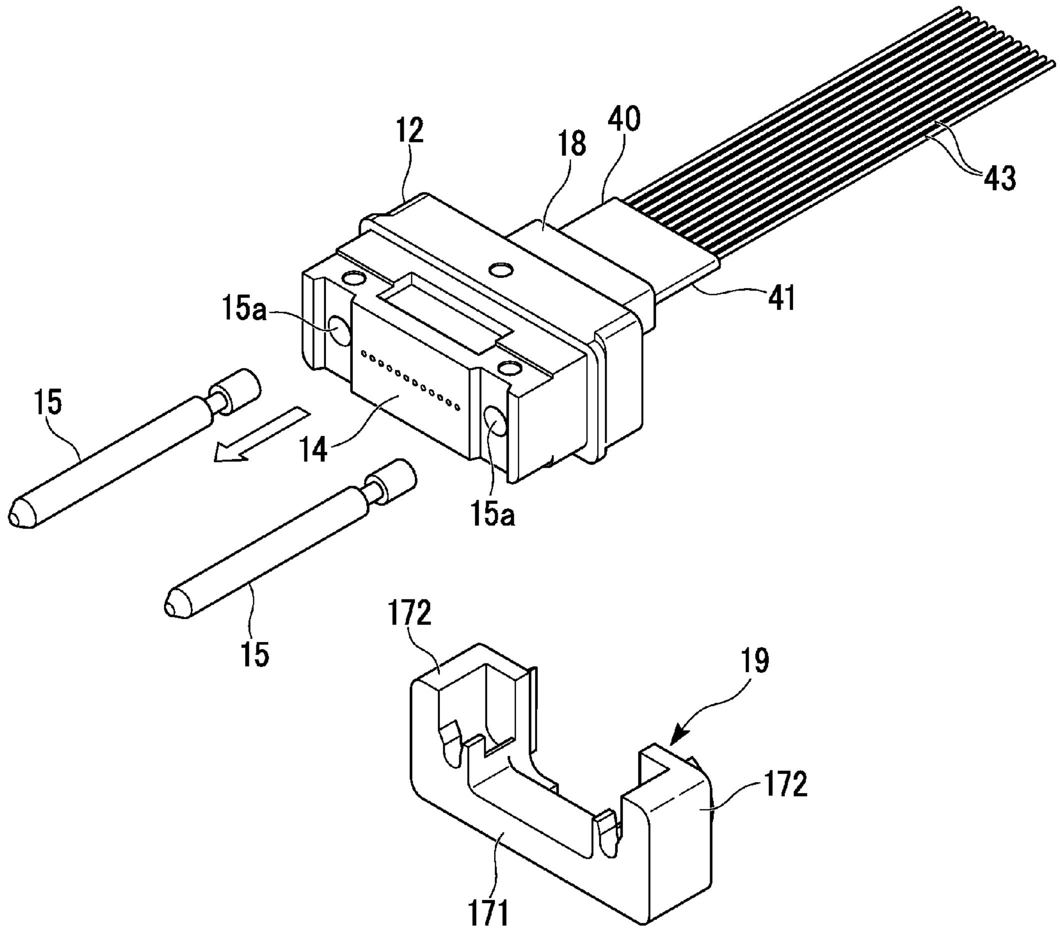


FIG. 28

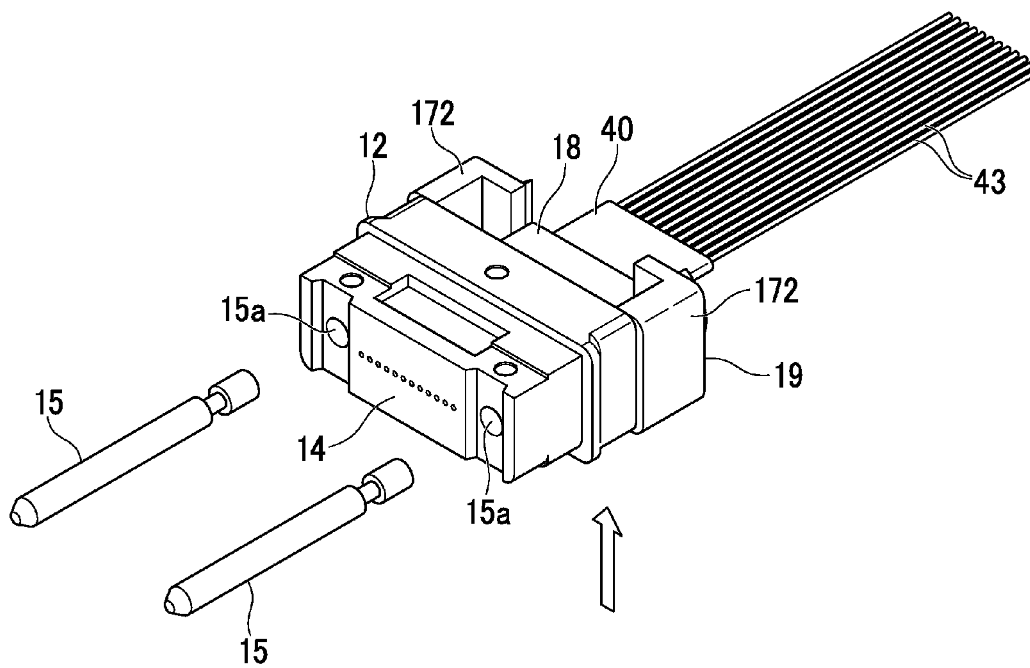


FIG. 29

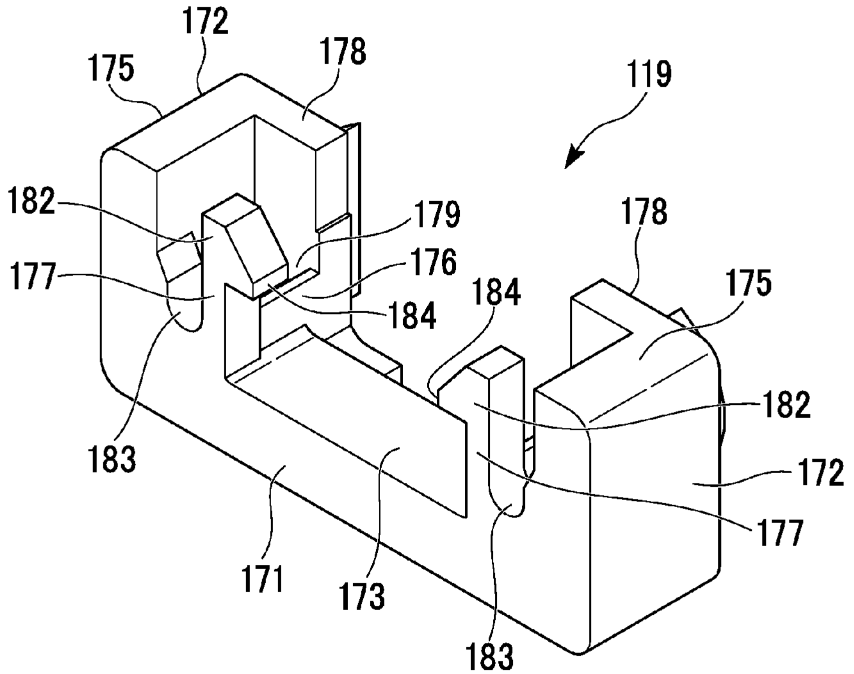
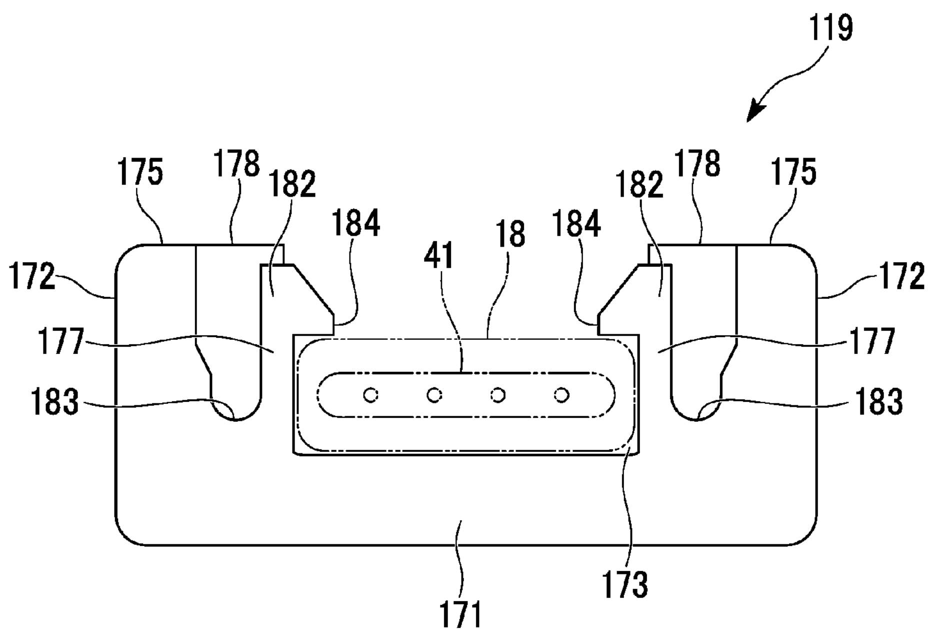

172
175
178
119
182
179
177
176
184
178
175
184
182
172
183
177
171
173
183

FIG. 30


119
175
178
182
184
41
18
184
182
178
175
172
172
177
177
183
183
173
171

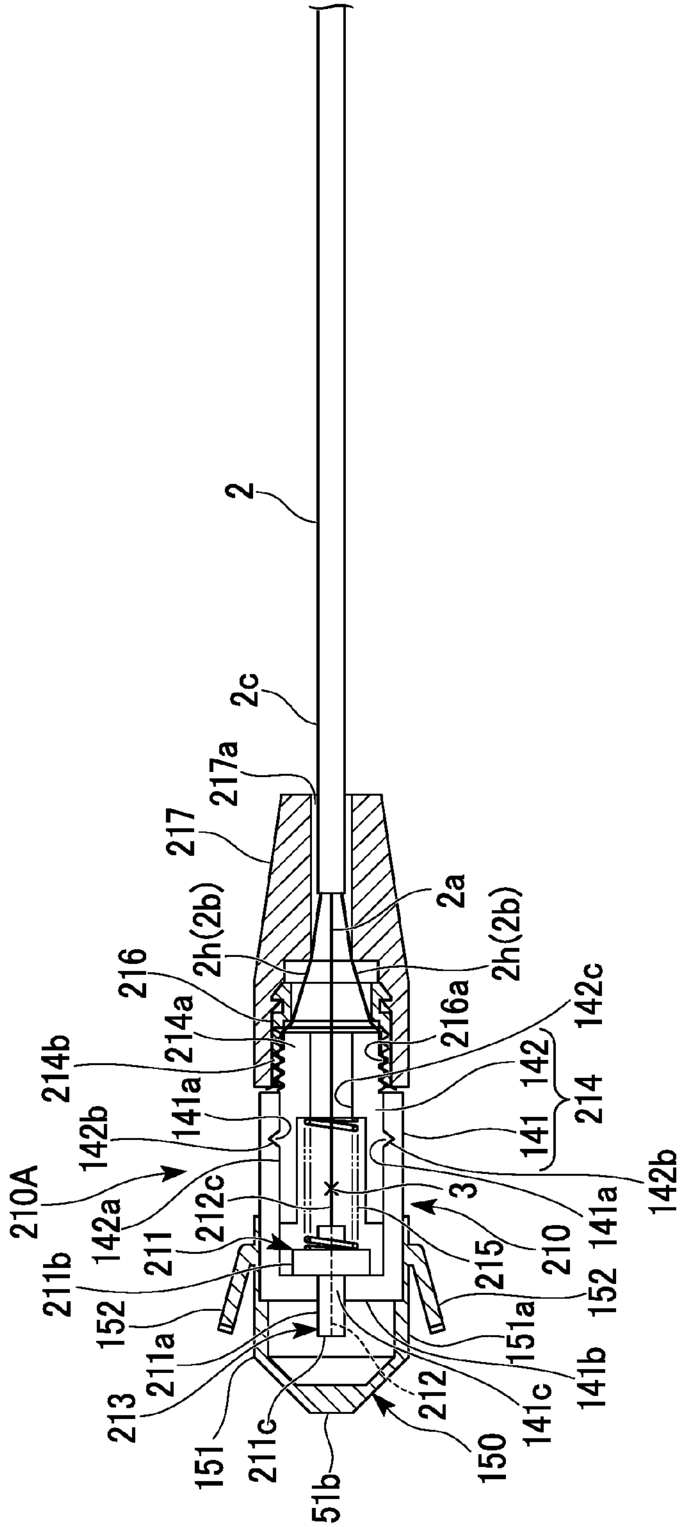

2
2c
217a
217
2a
2h(2b)
2h(2b)
216
216a
214a
142c
214b
142
141a
214
141
142b
142b
210A
142a
212c
3
141a
211
215
210
211b
152
152
151a
211a
141b
213
212
141c
151
211c
150
151b

FIG. 31

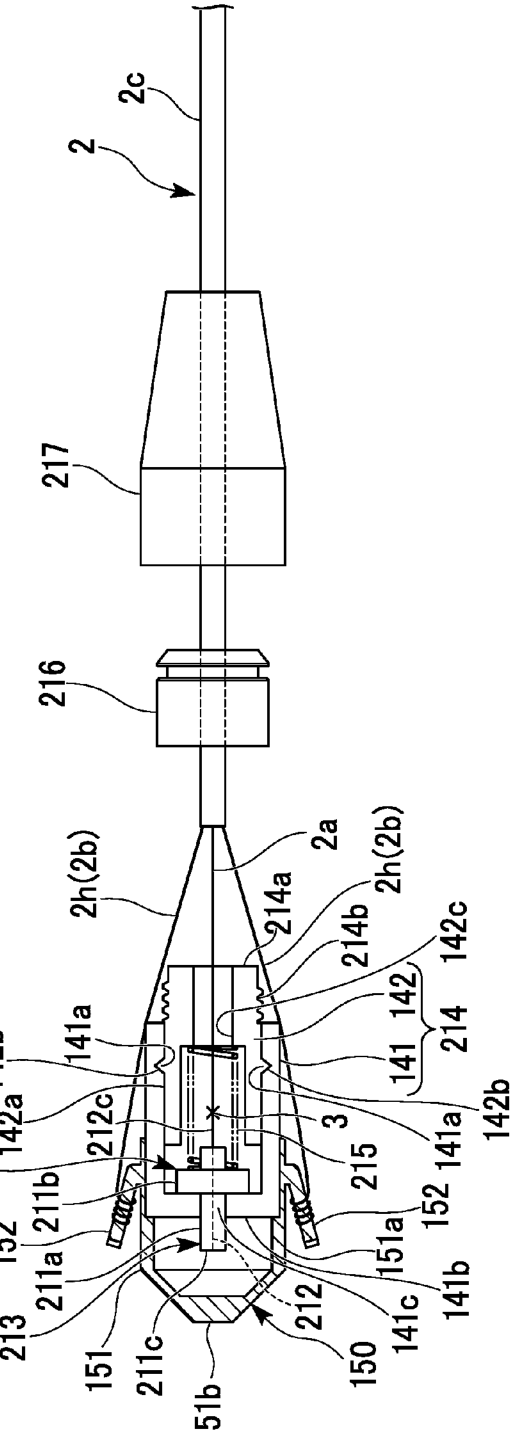


FIG. 32A

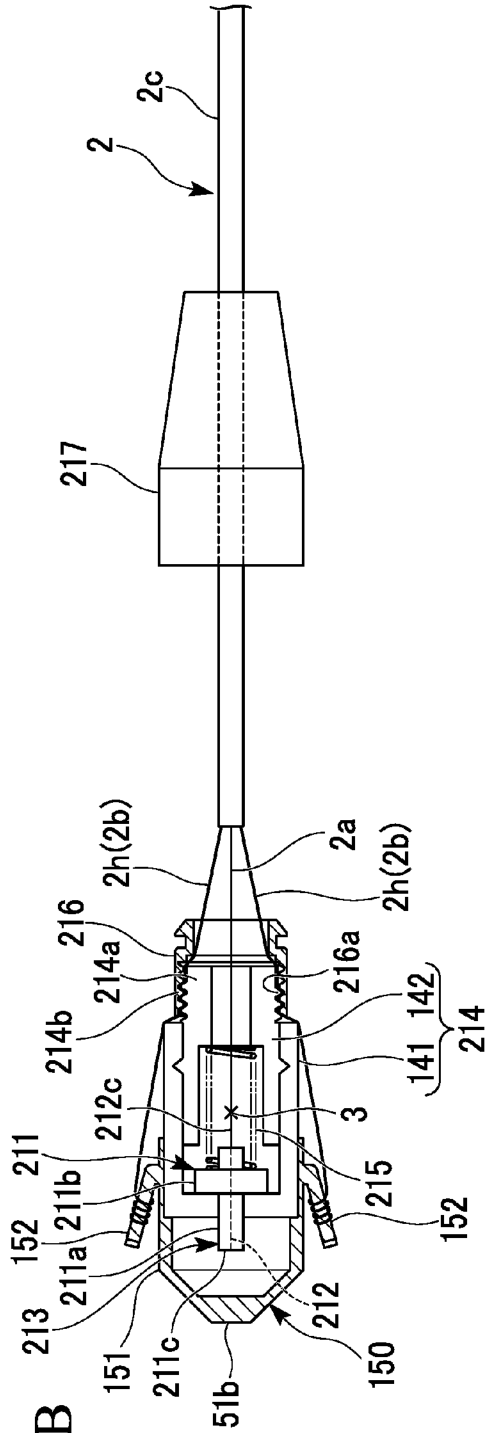


FIG. 32B

FIG. 33

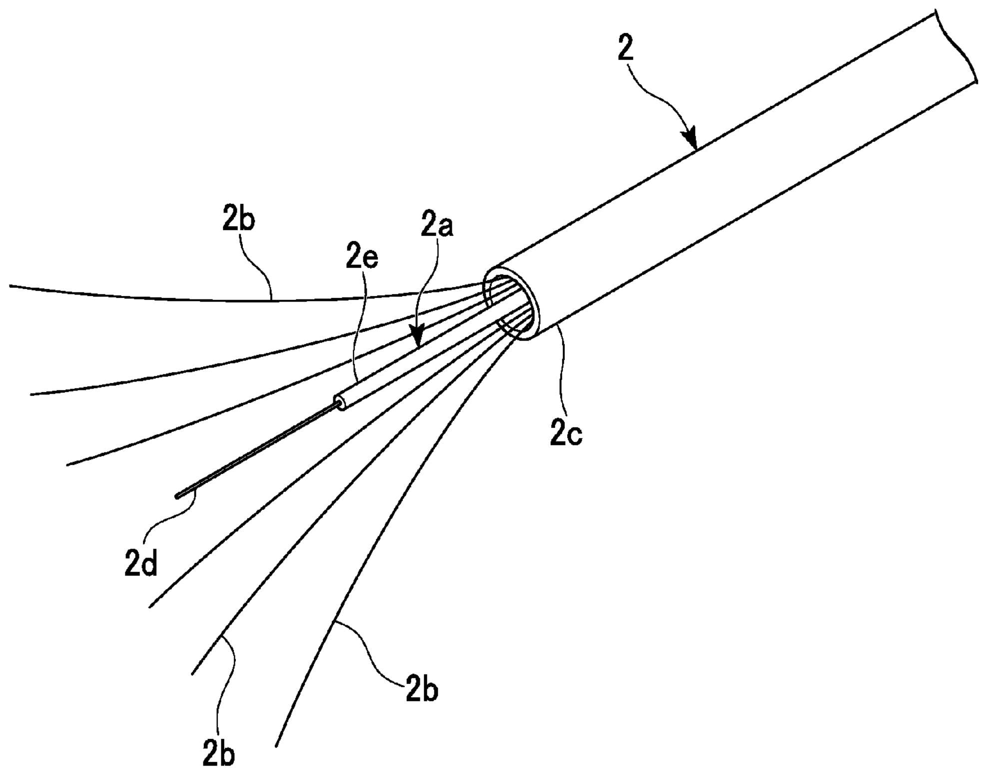
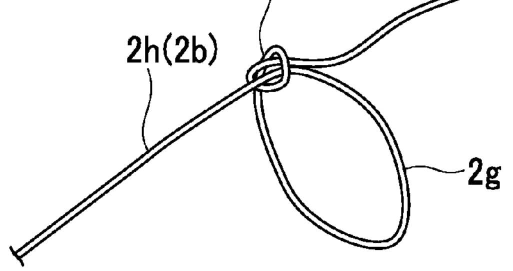


FIG. 34



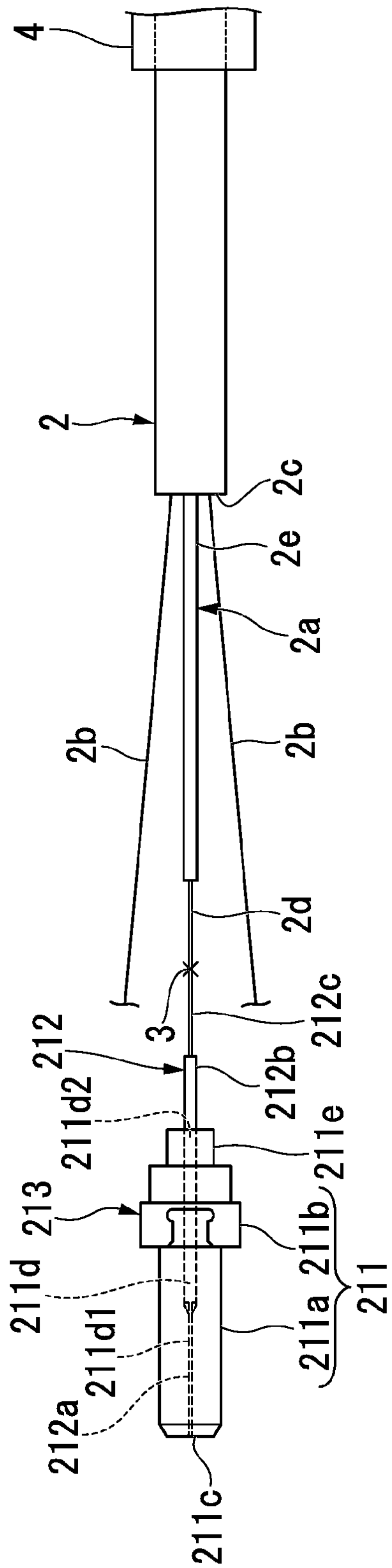
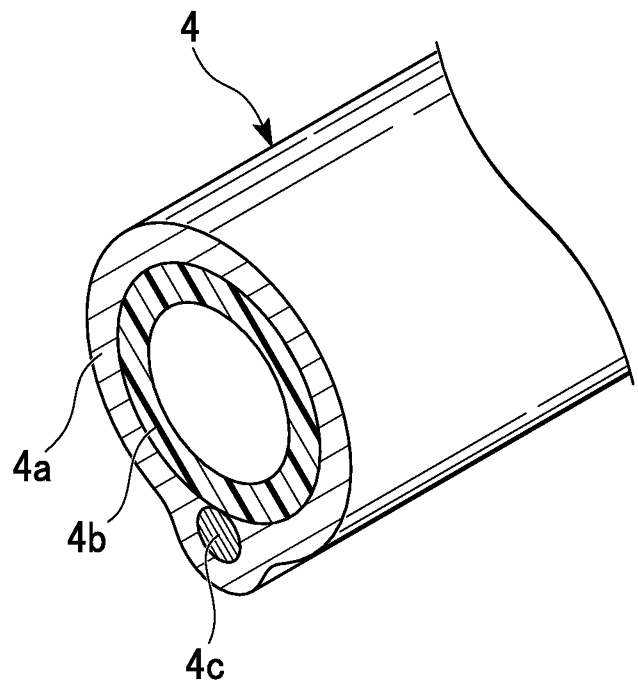

4
2
2c
2e
2a
2b
2b
2d
3
212c
212
212b
211d2
211e
213
211b
211
211d
211a
211d1
212a
211c

FIG. 35

FIG. 36



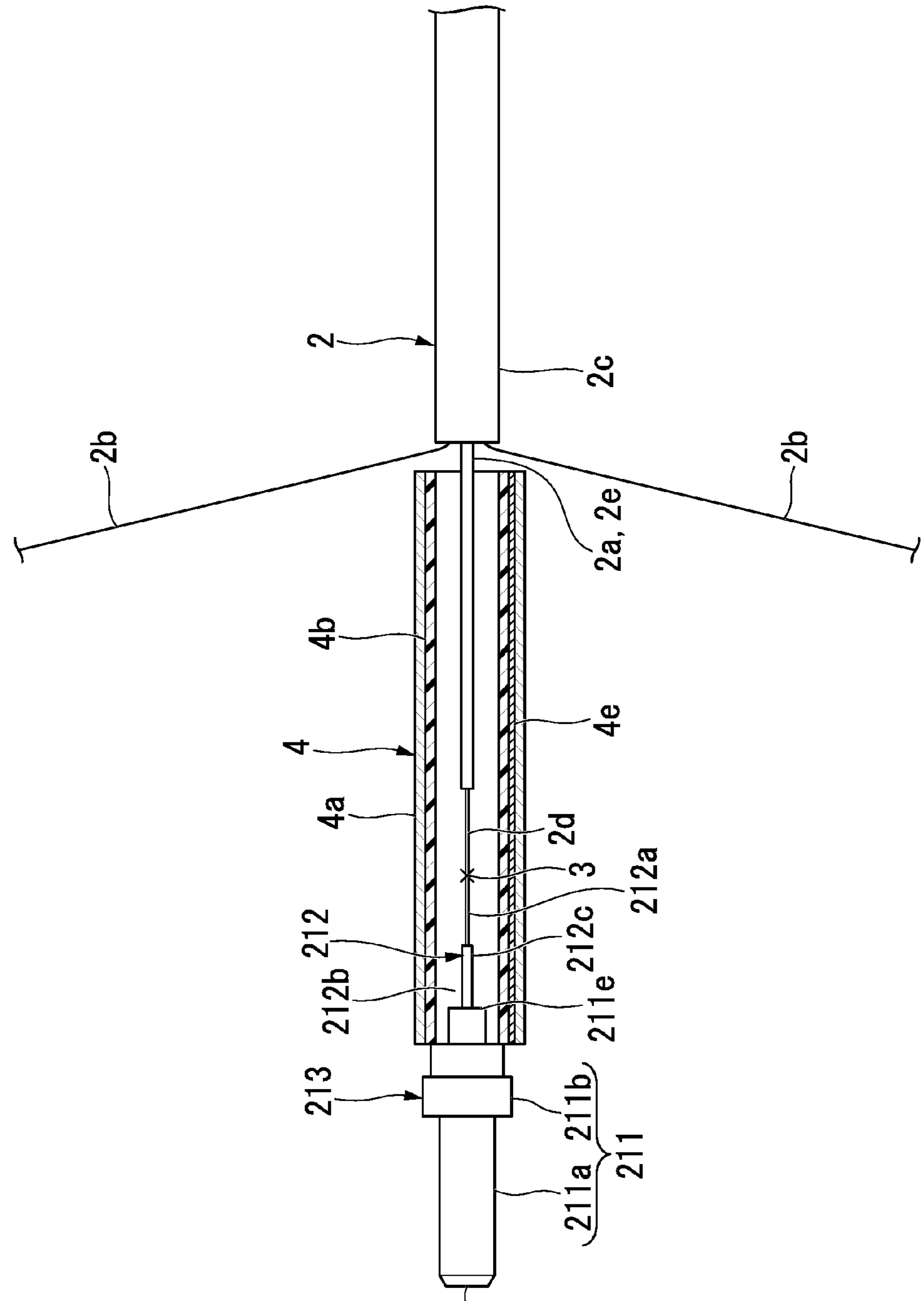

2
2c
2b
2b
2a, 2e
4b
4e
4
4a
2d
3
212a
212
212c
212b
211e
213
211b
211
211a
211c

FIG. 37

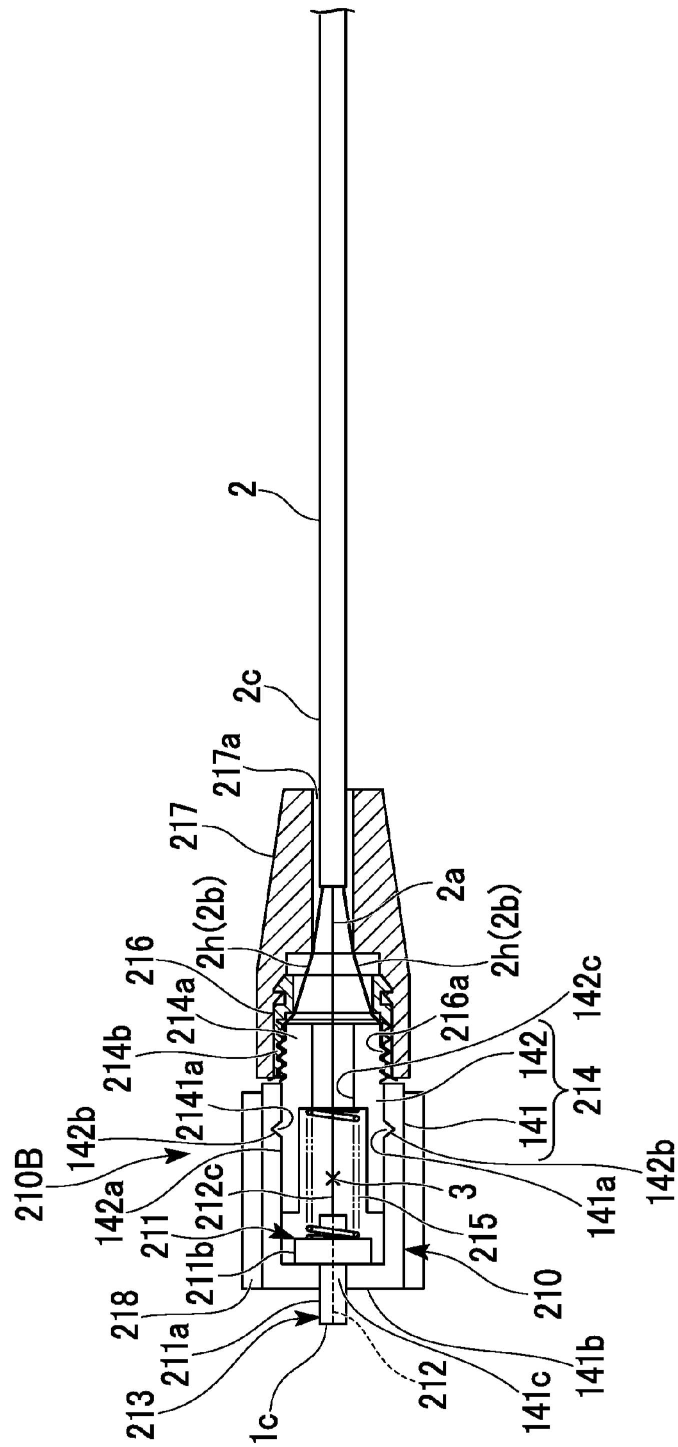

2
2c
217a
217
2a
2h(2b)
2h(2b)
216
216a
214a
214b
142c
142
214
141
2141a
142b
210B
142a
212c
3
215
141a
142b
211
211b
210
218
211a
213
212
211c
141c
141b

FIG. 38

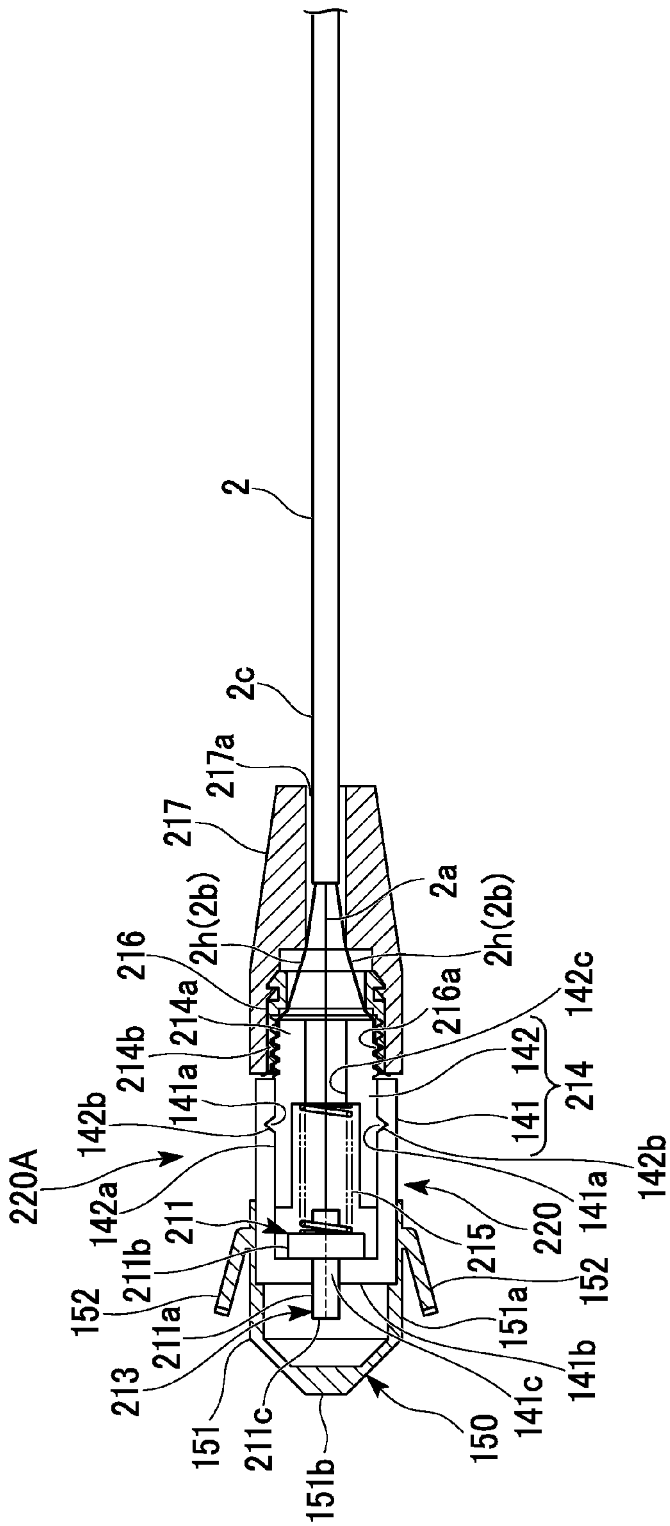

2
2c
217a
217
2a
2h(2b)
2h(2b)
216
214a
216a
142c
214b
142
141a
214
141
142b
141a
142b
220A
142a
211
220
215
211b
152
152
151a
211a
141b
213
141c
151
211c
150
151b

FIG. 39

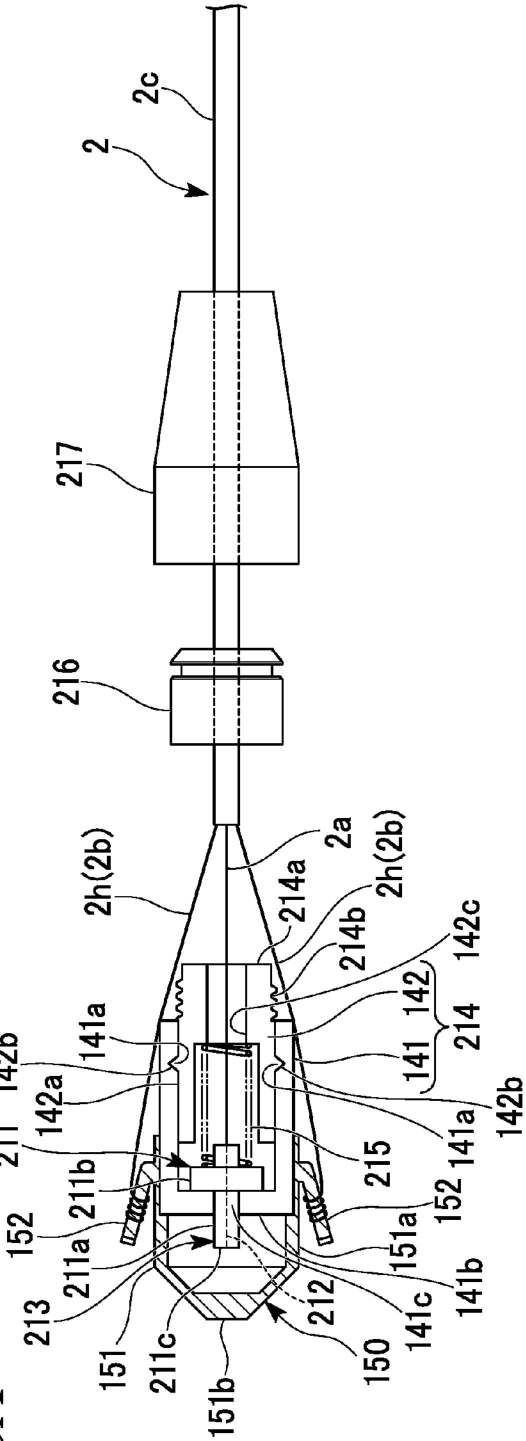


FIG. 40A

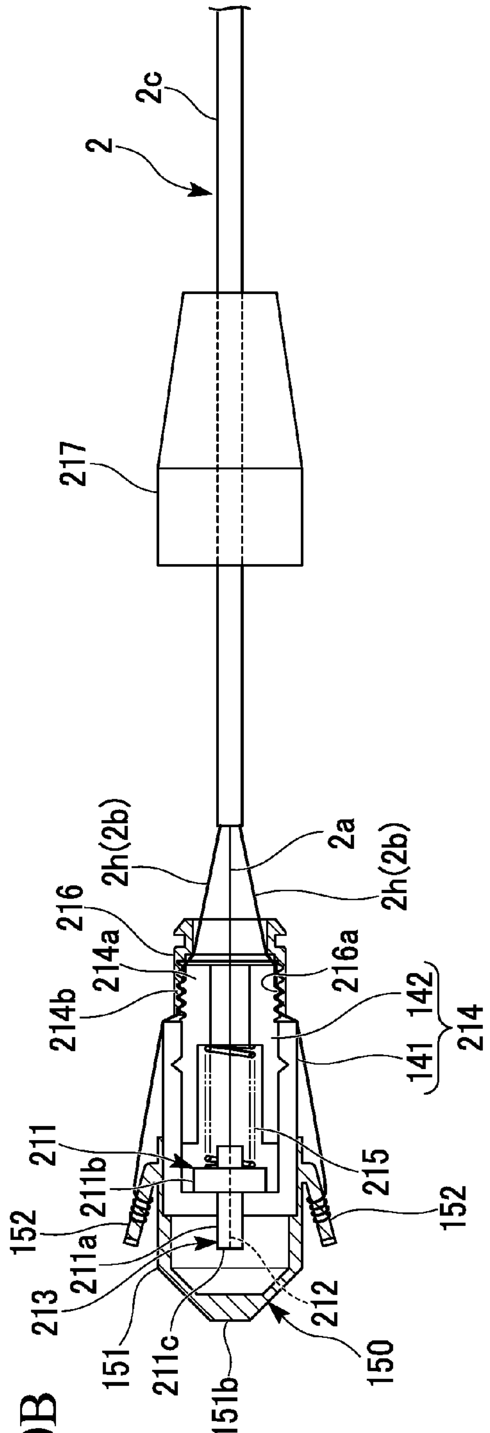


FIG. 40B

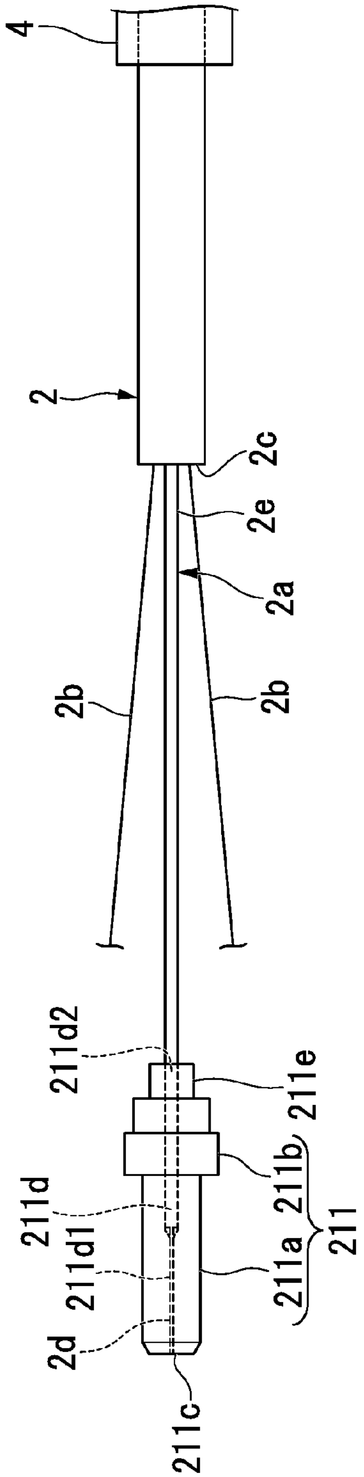


FIG. 41

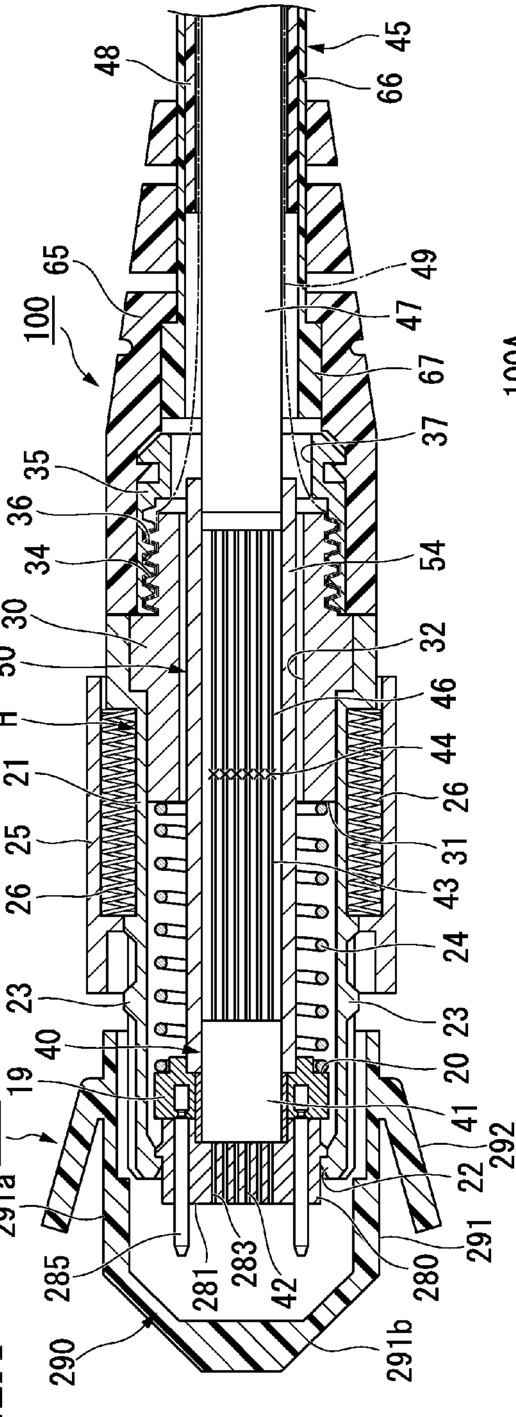


FIG. 42A

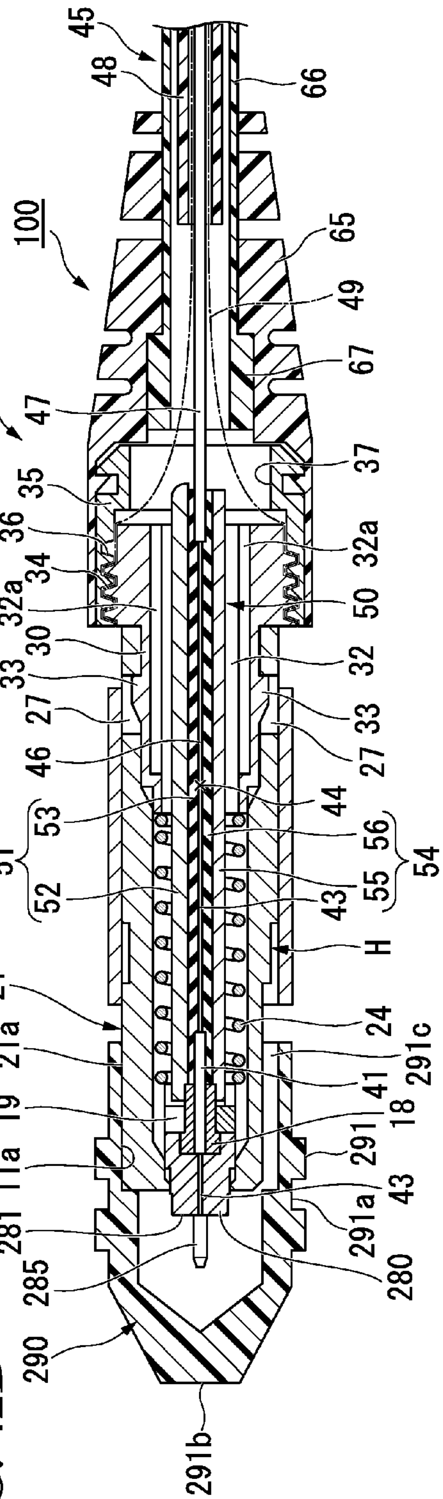


FIG. 42B

FIG. 43A

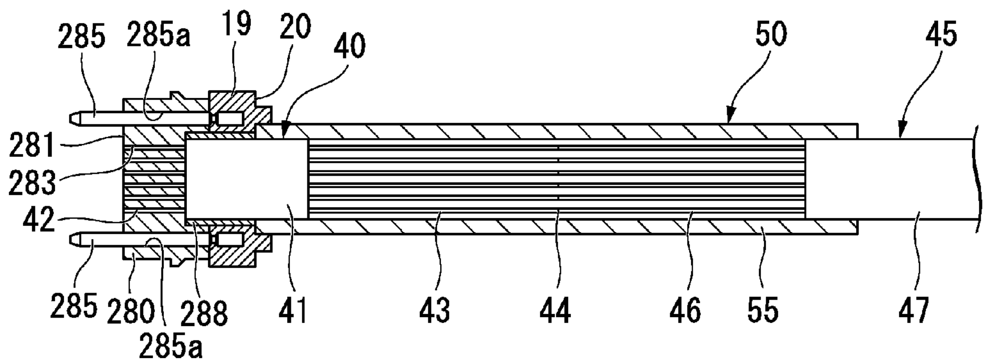


FIG. 43B

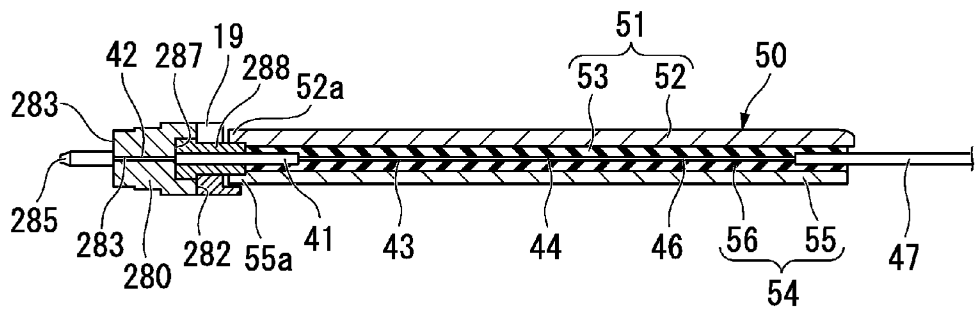


FIG. 44

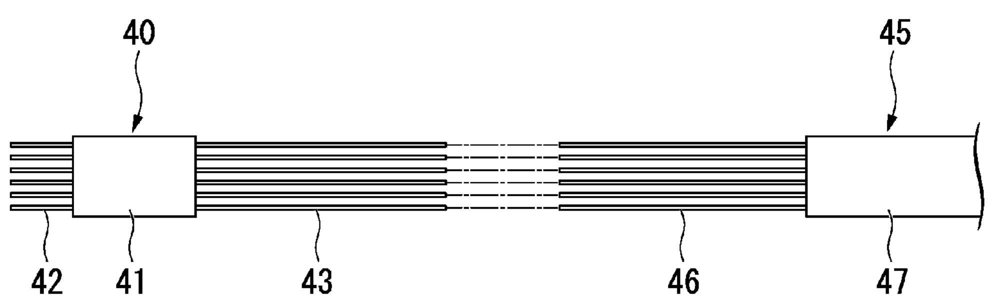


FIG. 45A

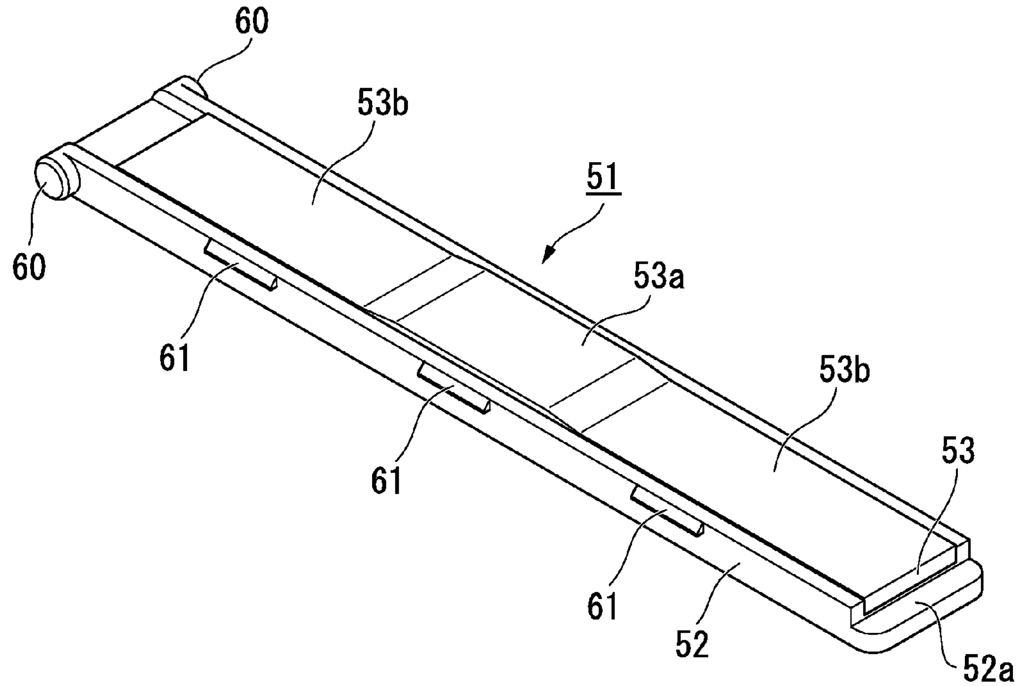


FIG. 45B

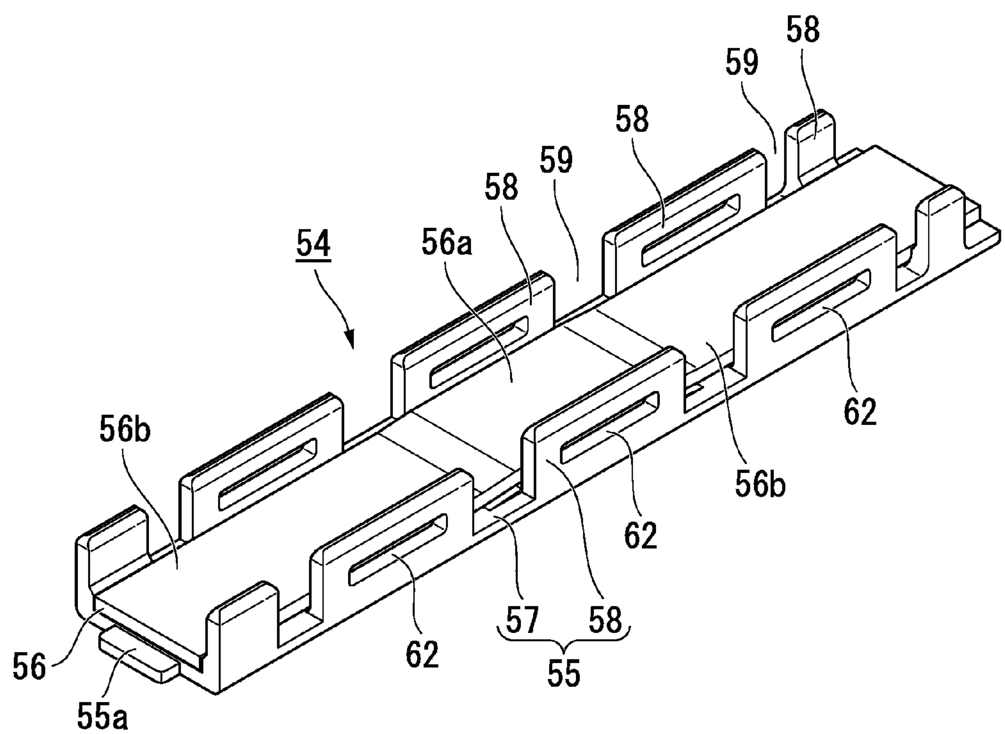


FIG. 46

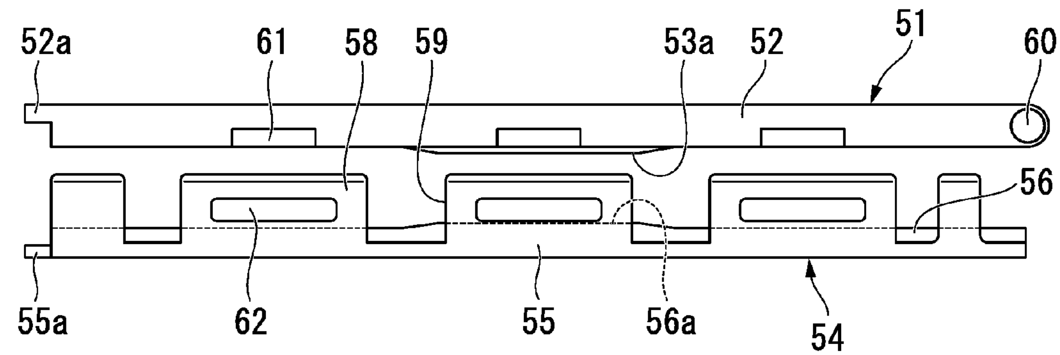


FIG. 47

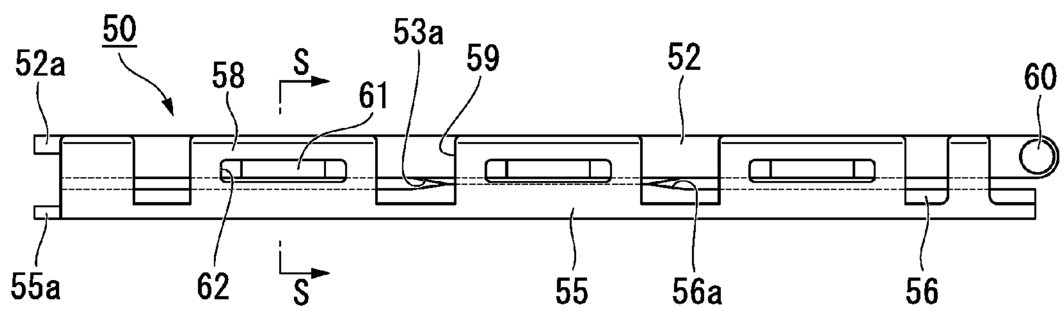


FIG. 48

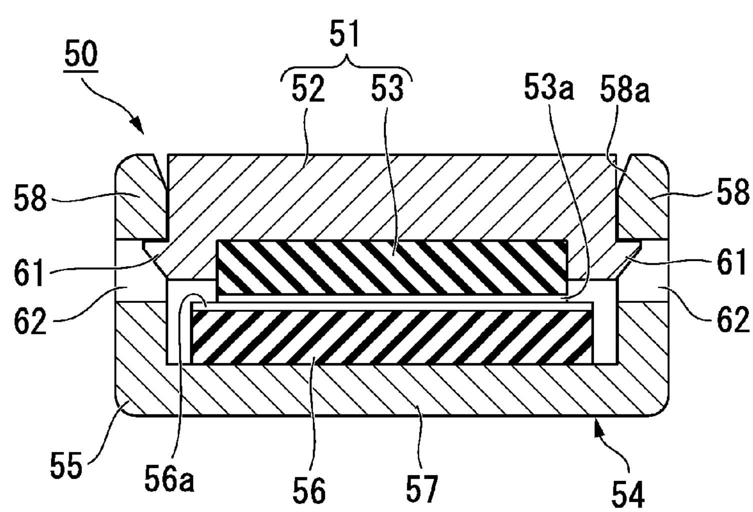


FIG. 49

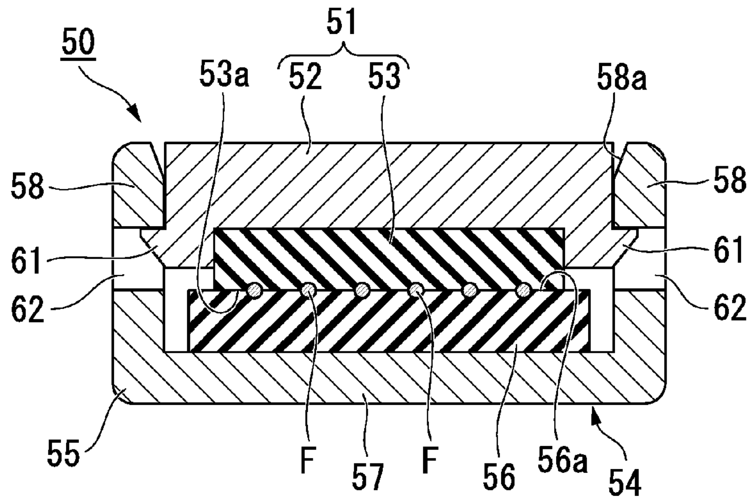

50
51
53a
52
53
58a
58
58
61
61
62
62
55
F
57
F
56
56a
54

FIG. 50

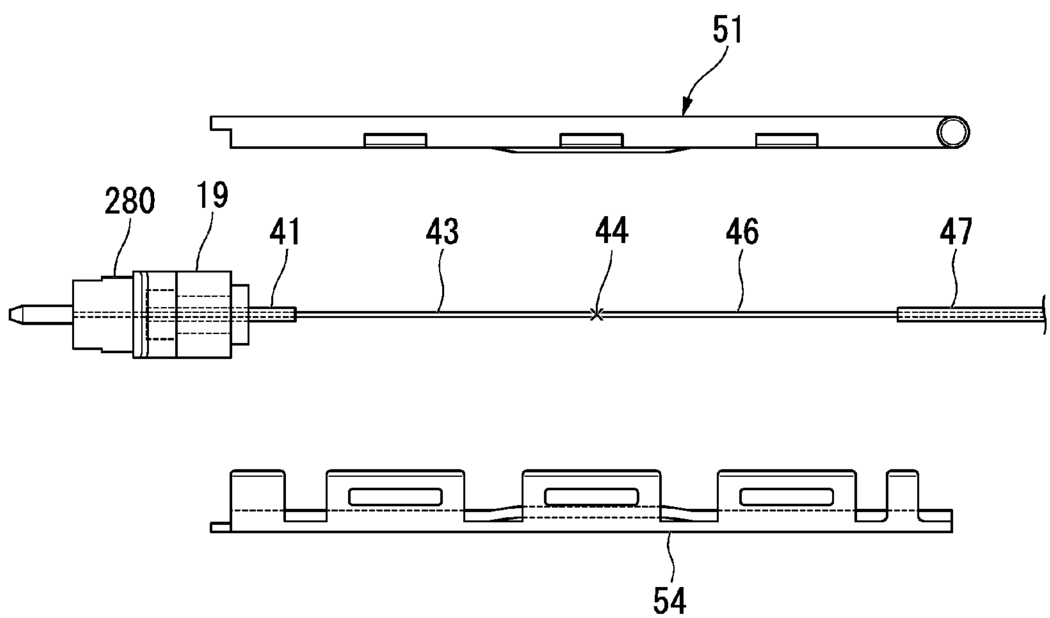

51
280
19
41
43
44
46
47
54

FIG. 51A

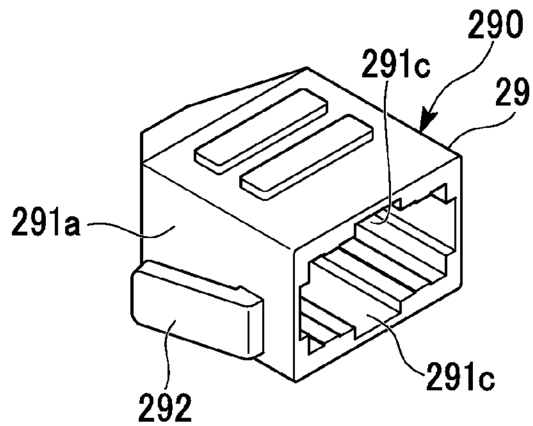


FIG. 51B

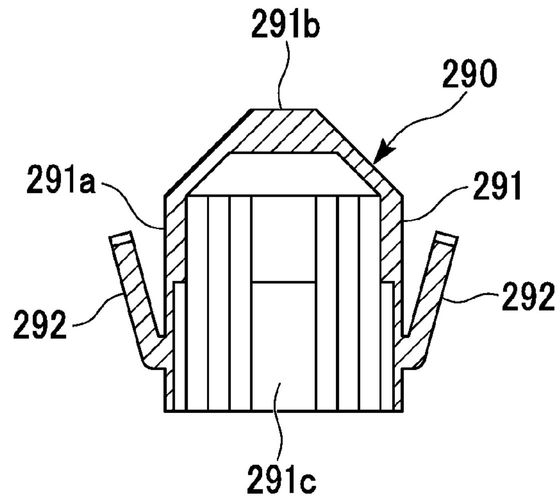


FIG. 51C

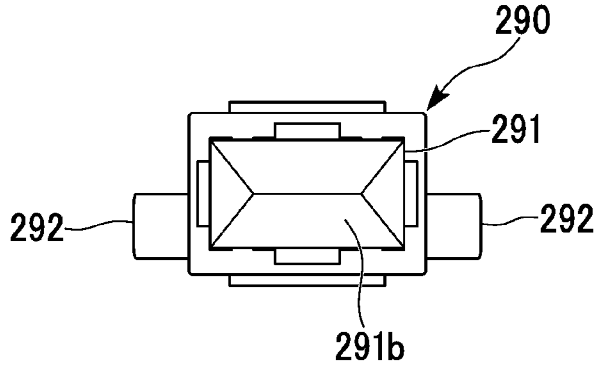
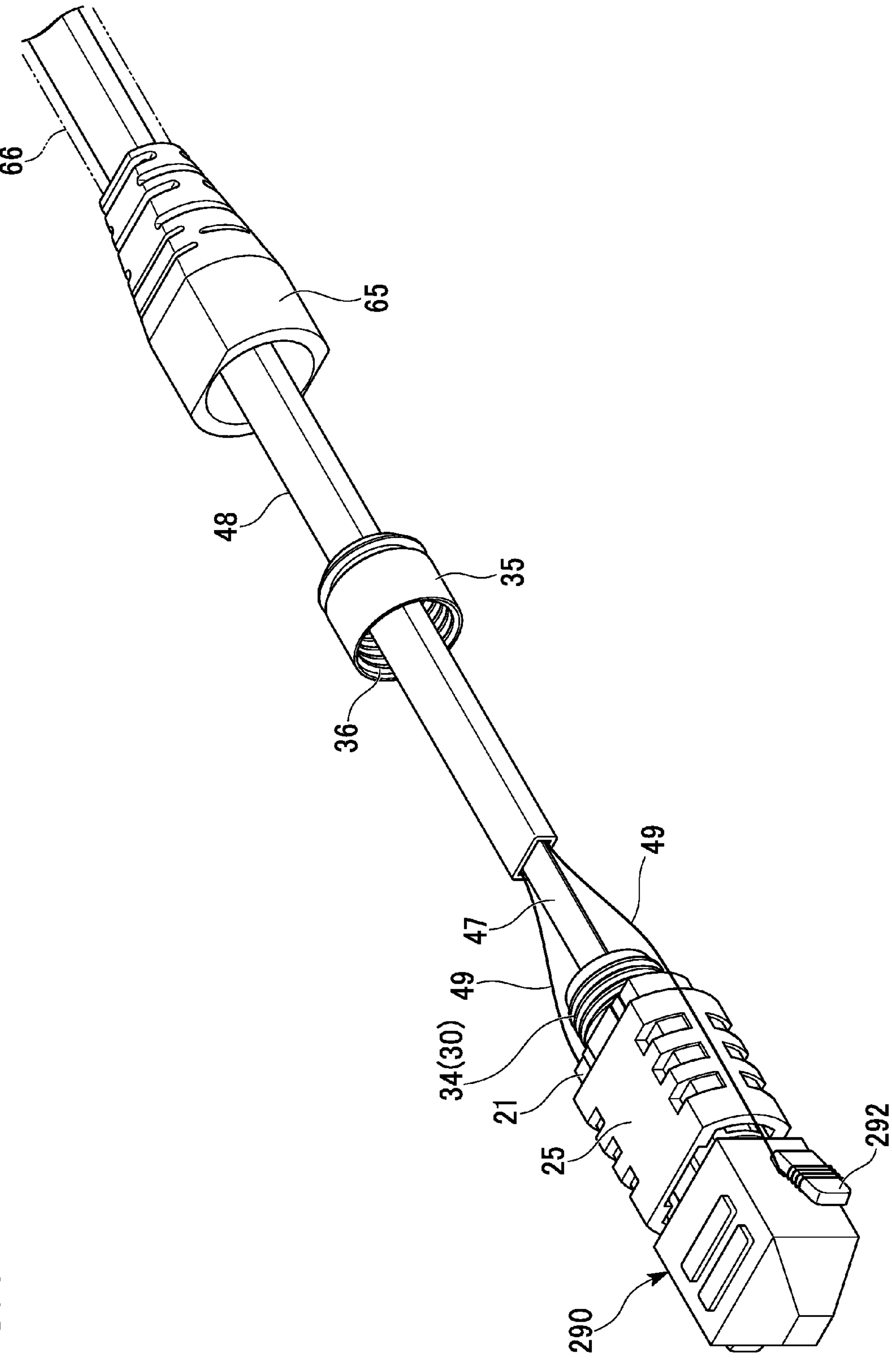


FIG. 52



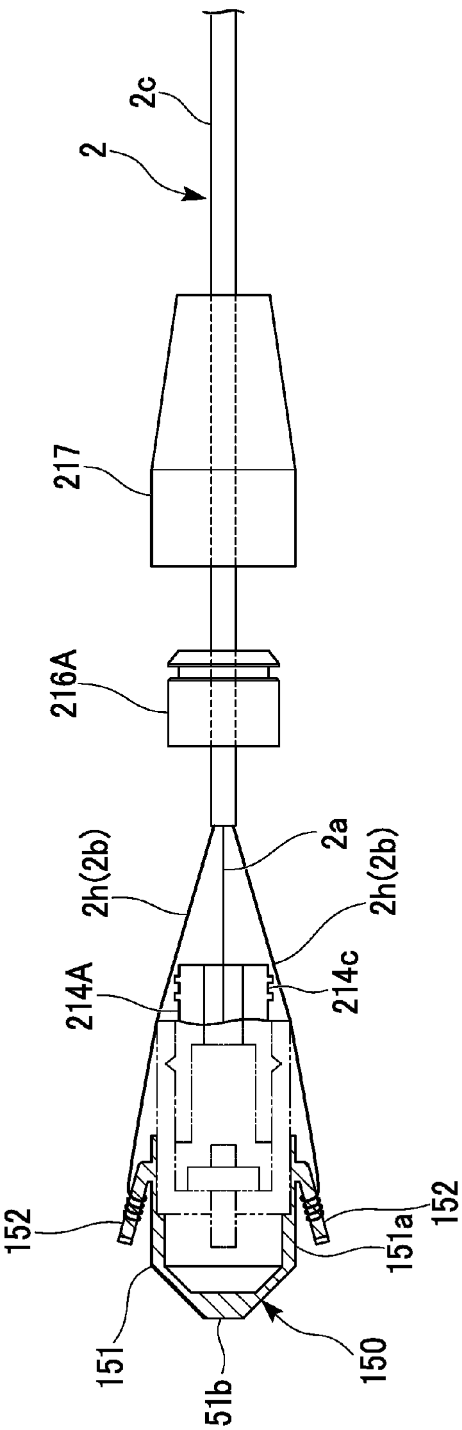


FIG. 53A

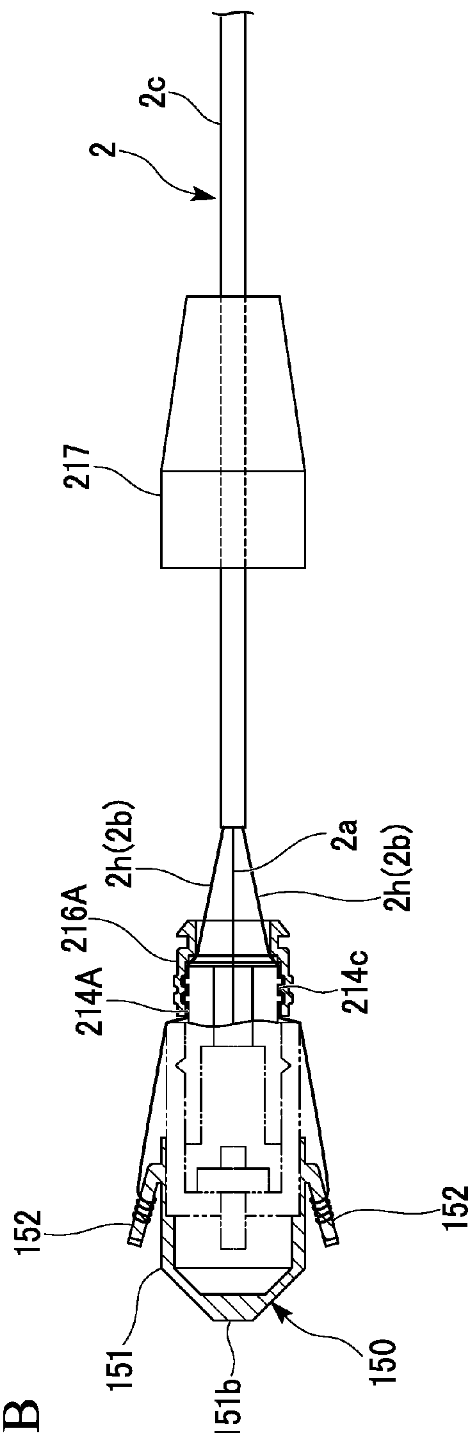
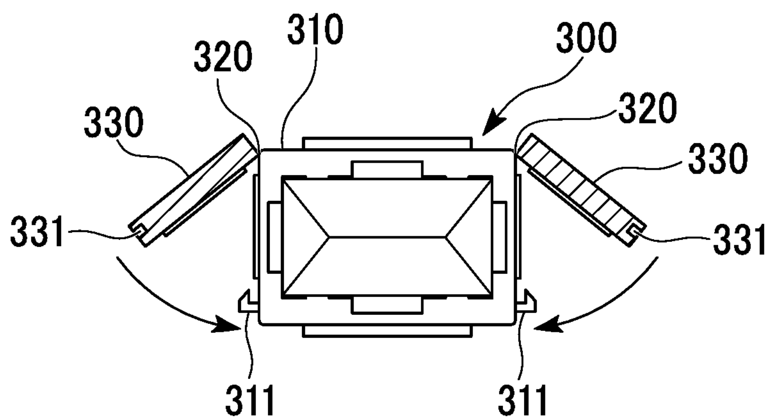


FIG. 53B

FIG. 54



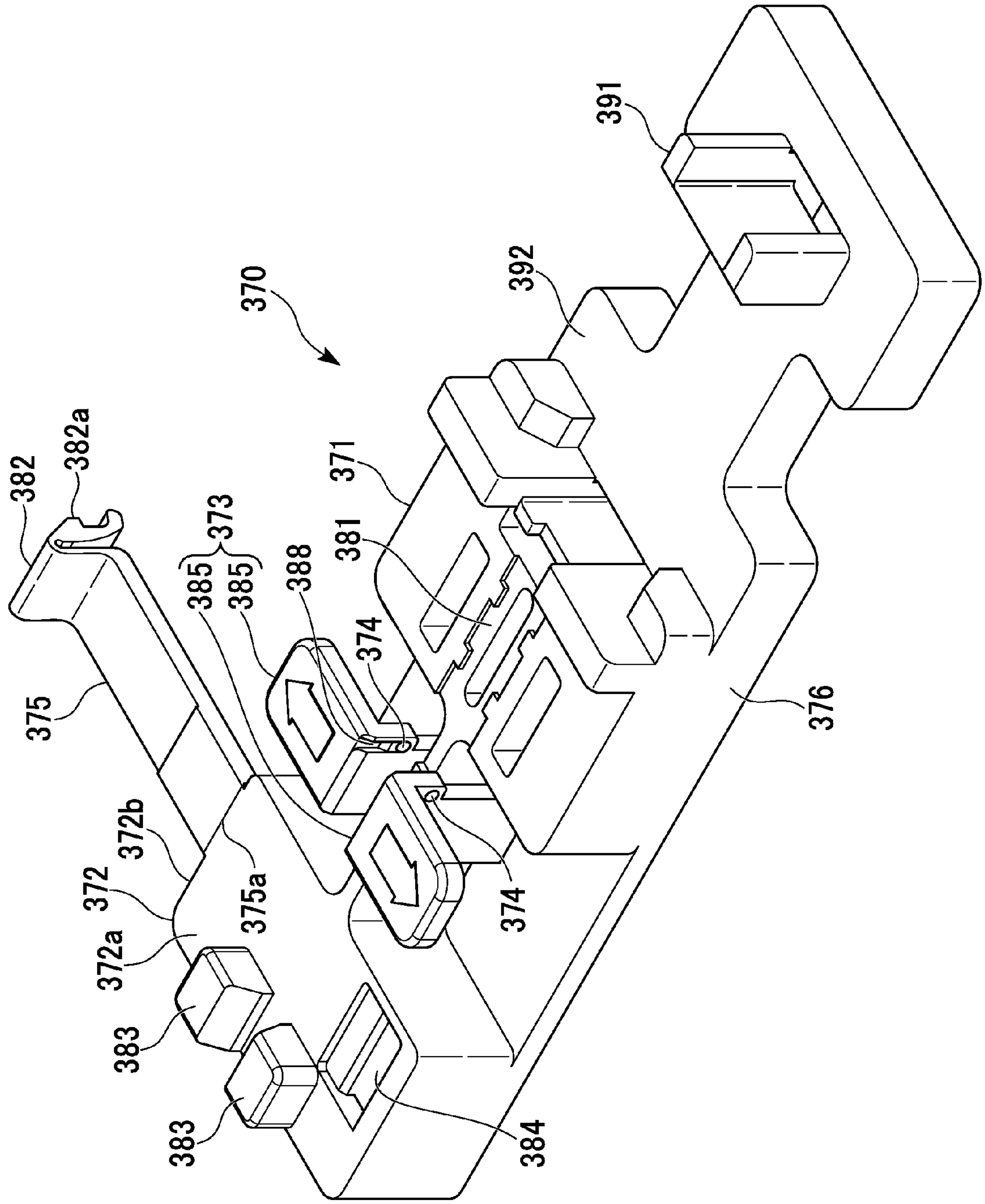

370
391
392
371
382
382a
373
385
385
388
381
374
374
375
376
372b
372
372a
375a
383
383
384

FIG. 55

FIG. 56

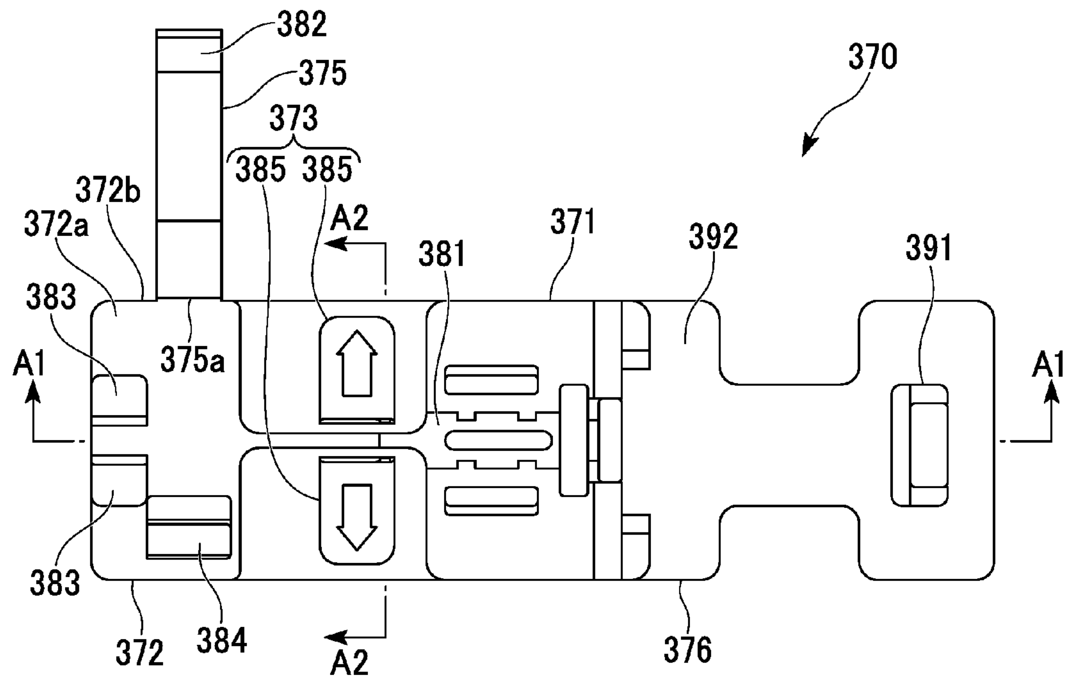


FIG. 57

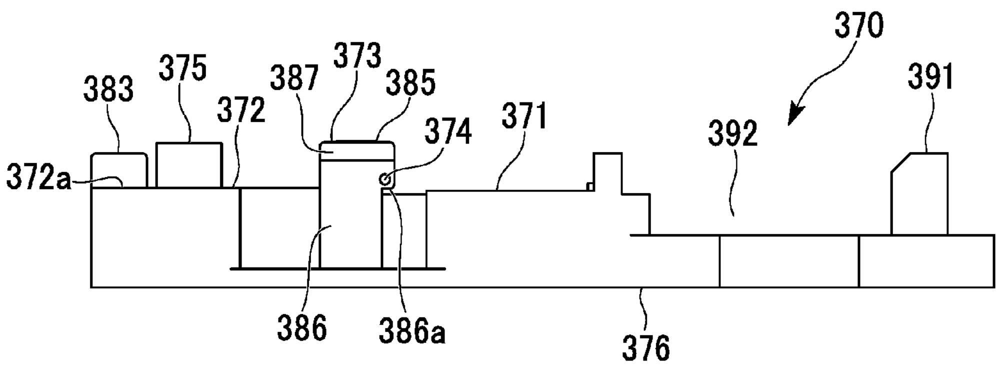


FIG. 58

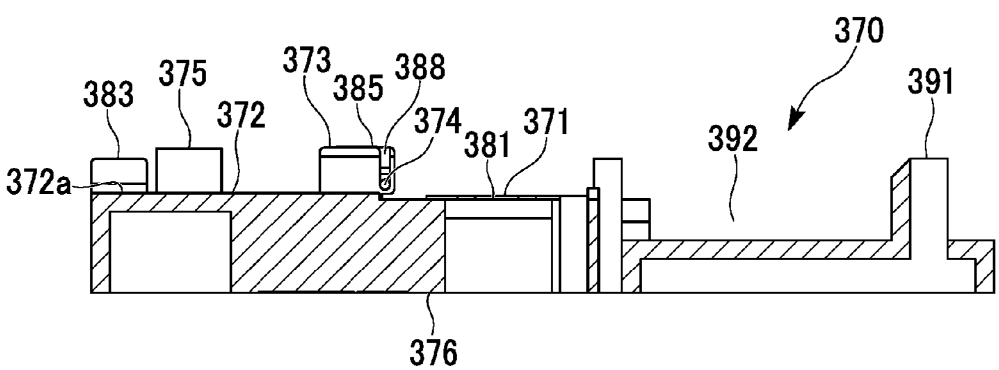


FIG. 59

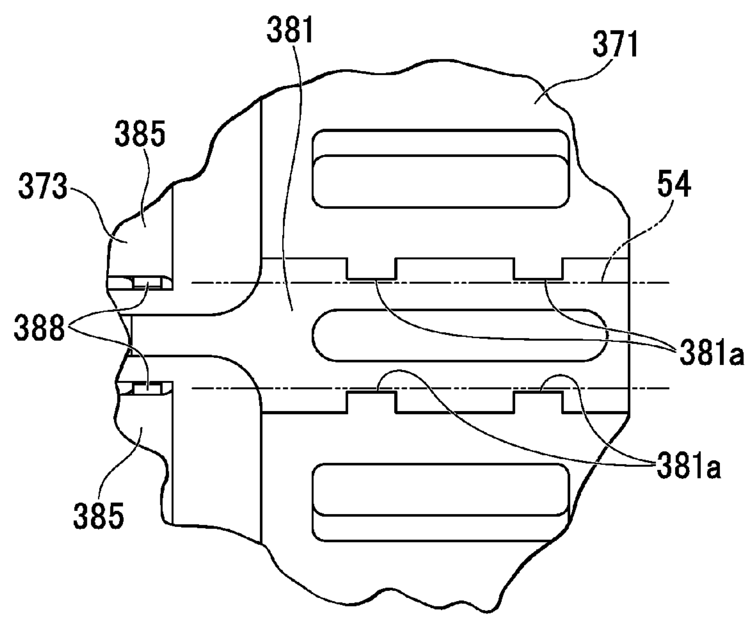
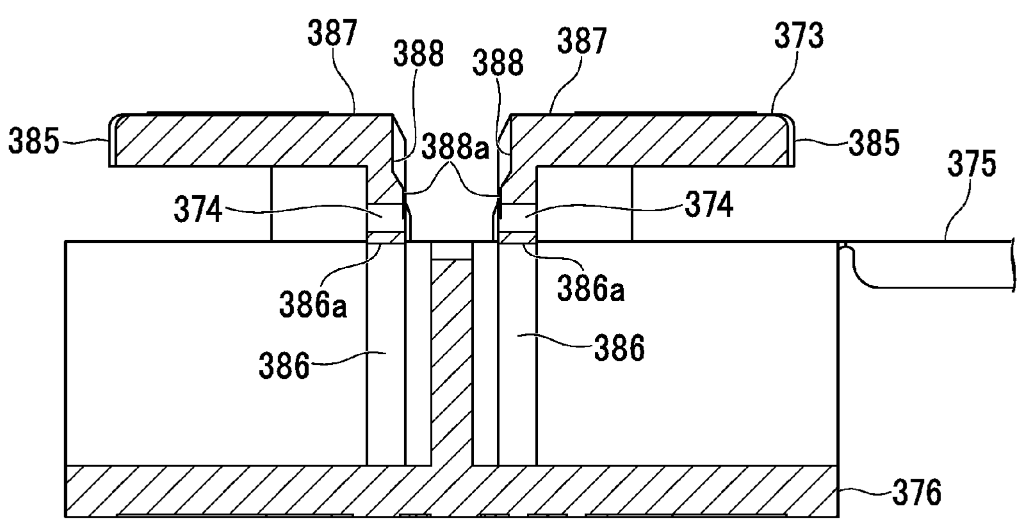

381
371
385
373
54
388
381a
381a
385

FIG. 60


387
388
388
387
373
385
388a
385
375
374
374
386a
386a
386
386
376

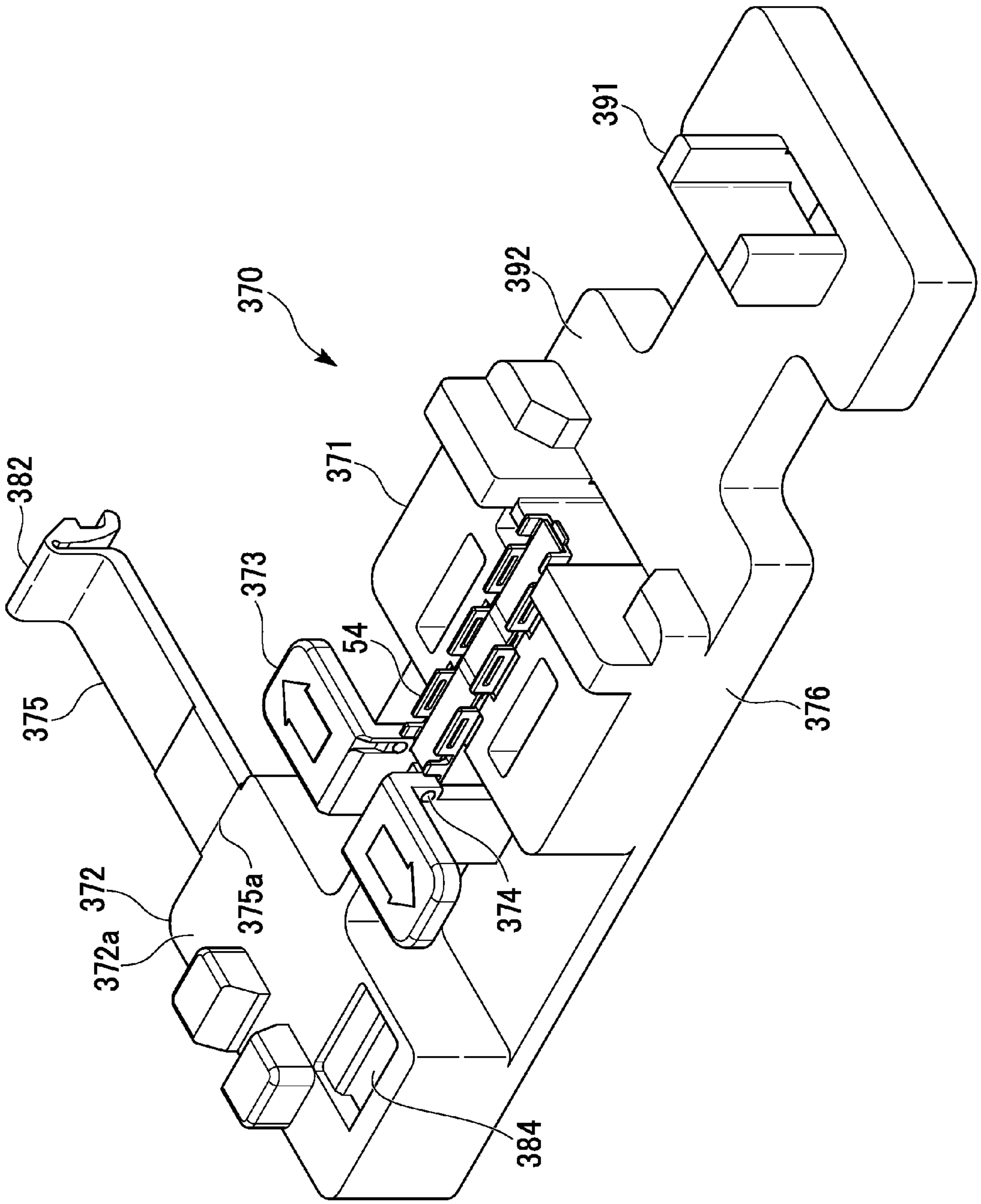


FIG. 61

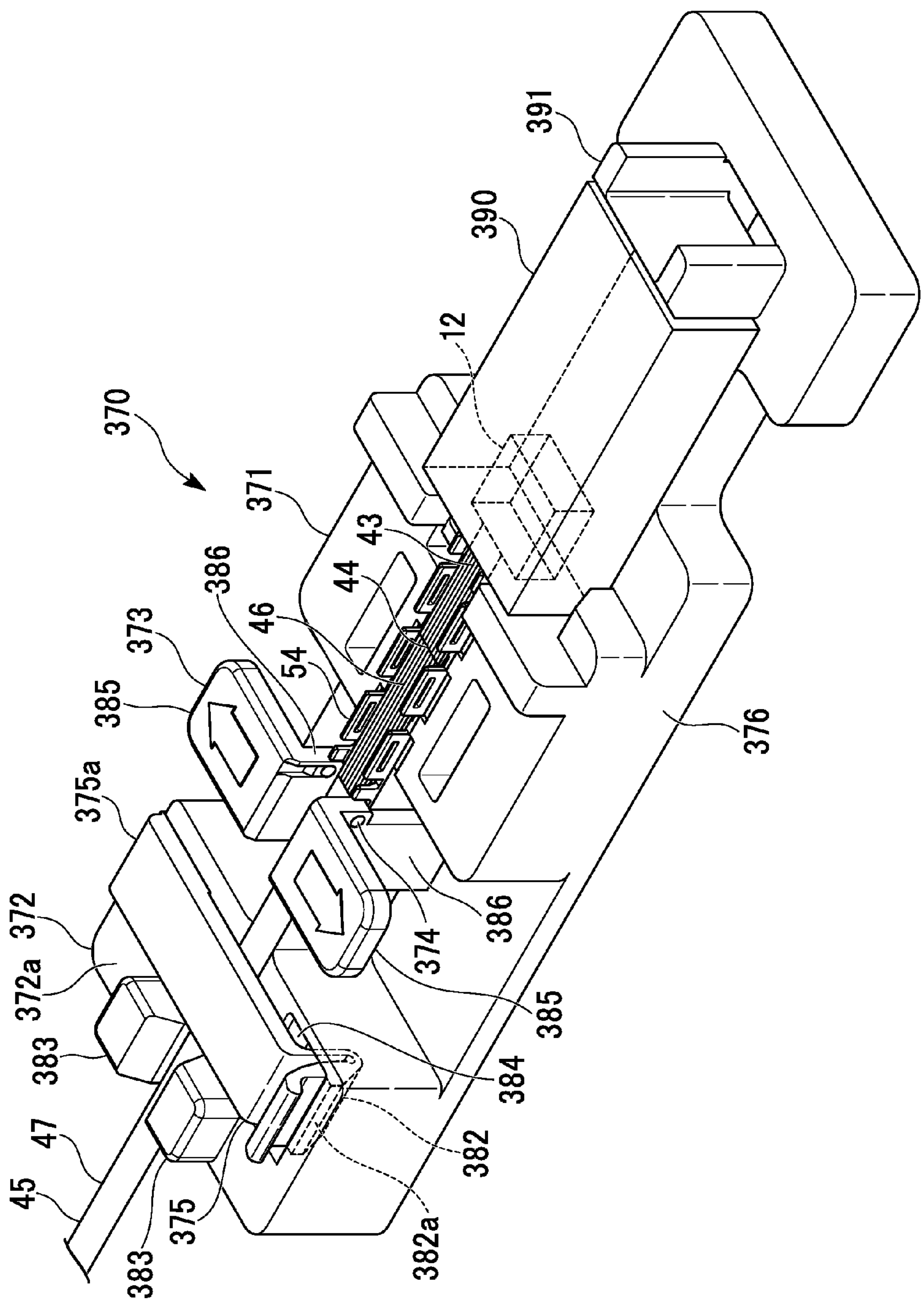

370
371
391
390
12
43
44
46
54
386
373
385
375a
372
372a
383
47
45
375
382a
382
384
385
386
374
376

FIG. 62

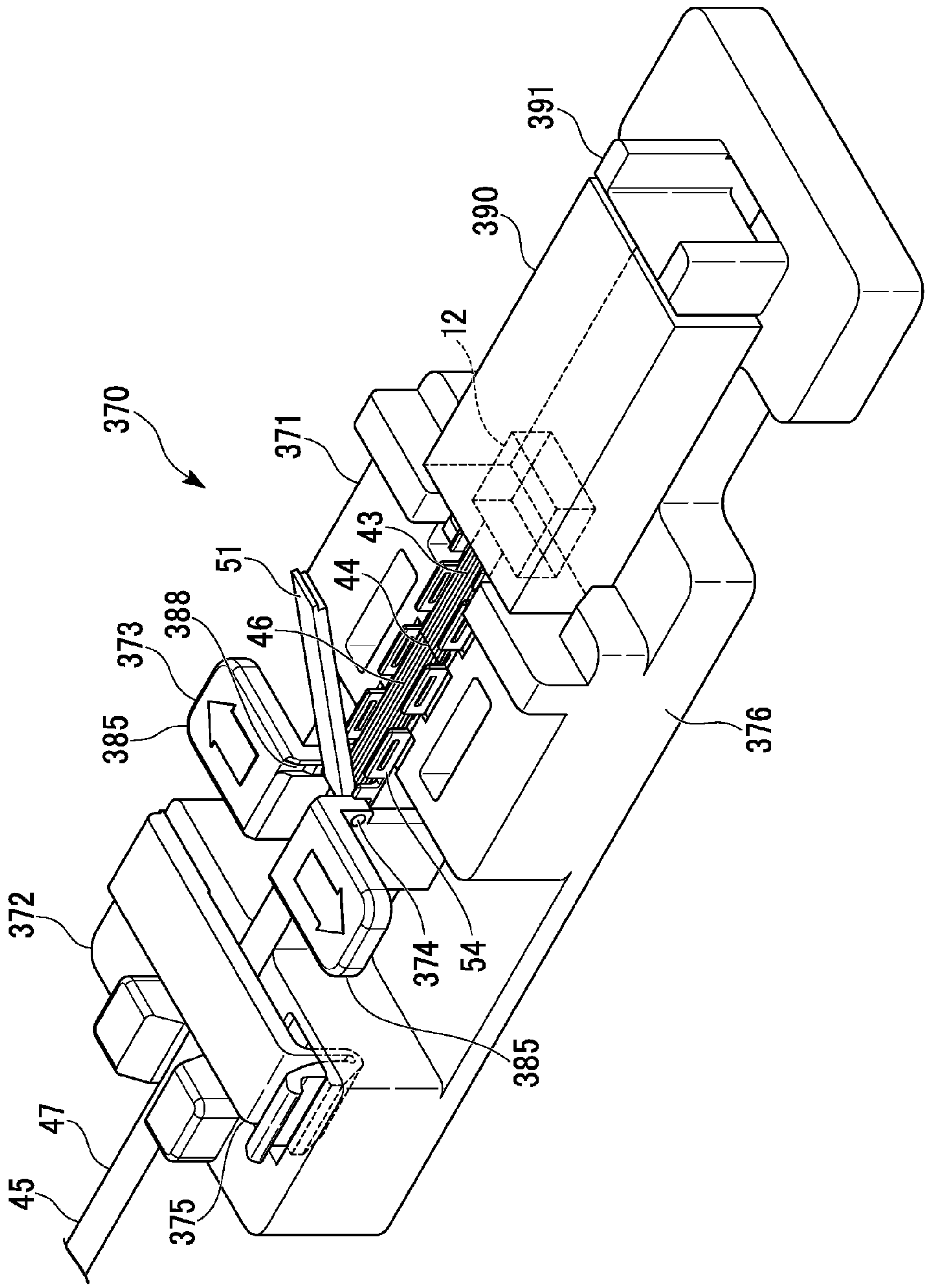

370
371
12
390
391
43
44
51
46
388
373
385
372
374
54
385
376
47
45
375

FIG. 63

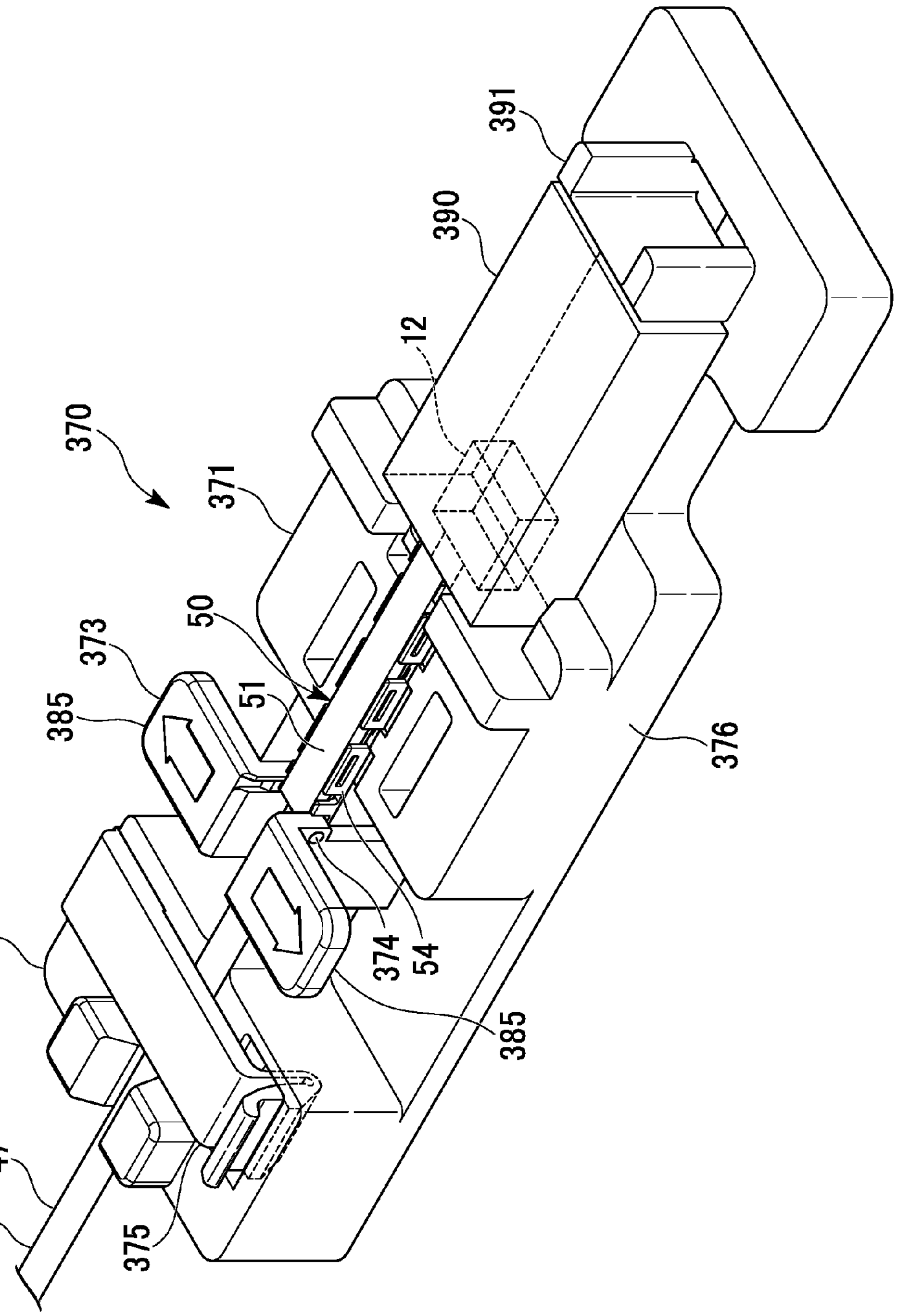
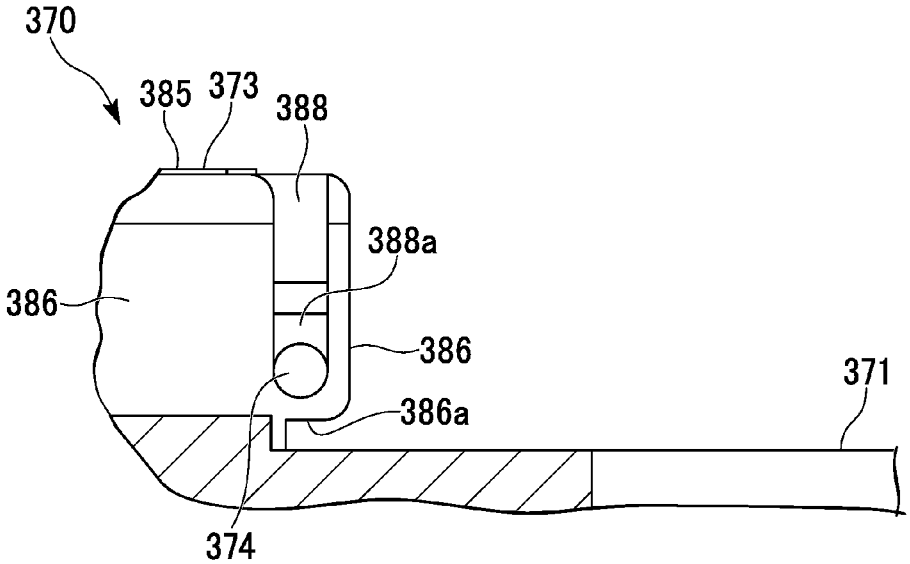


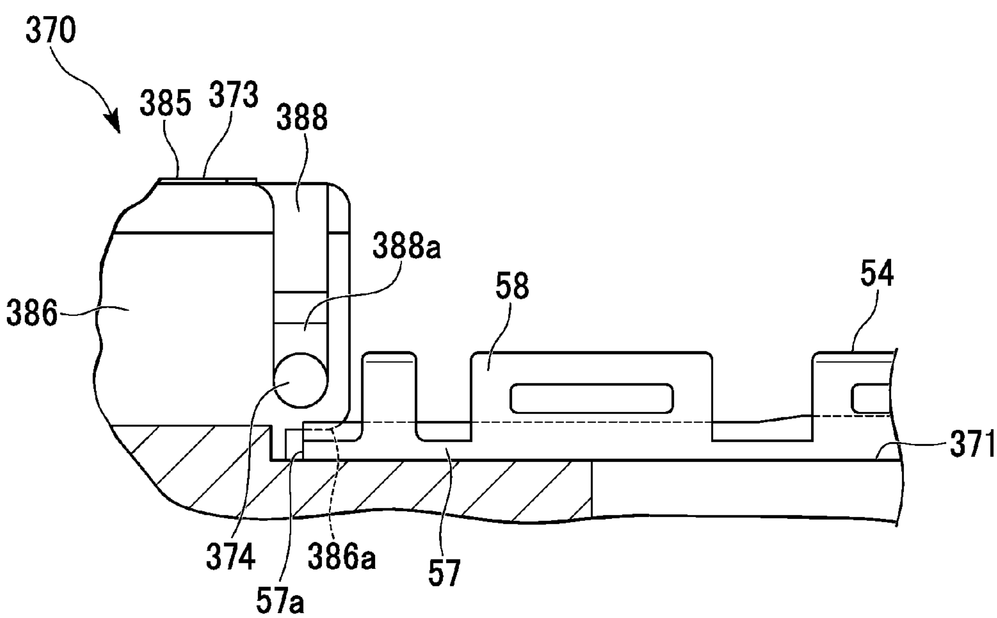
FIG. 64

FIG. 65



370
385
373
388
388a
386
386
371
386a
374

FIG. 66



370
385
373
388
388a
58
54
386
371
374
386a
57
57a

FIG. 67

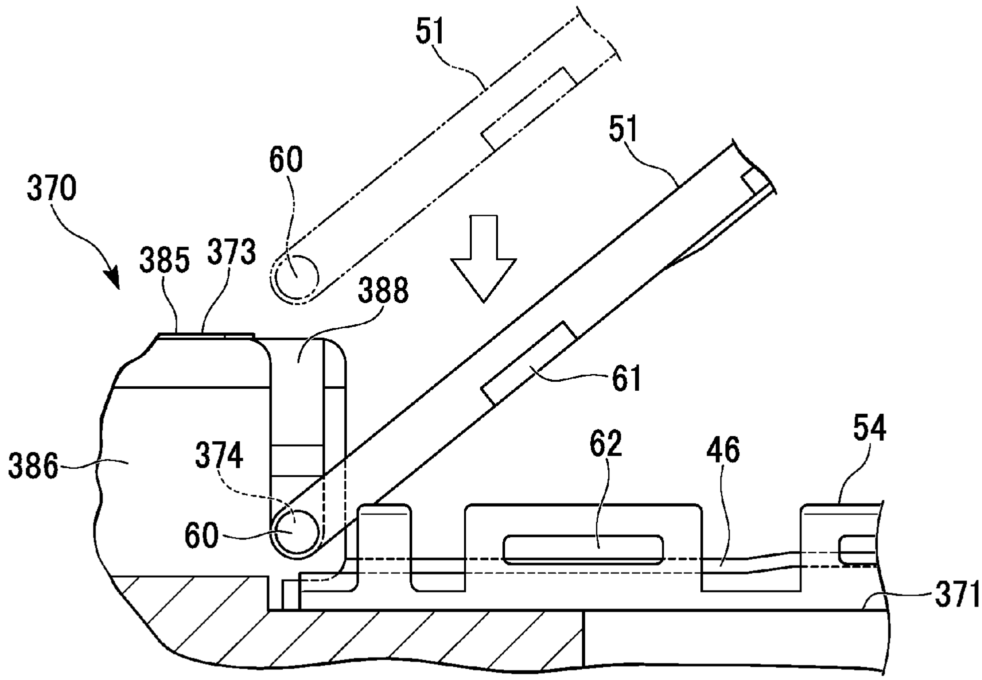

51
51
60
370
385
373
388
61
386
374
62
46
54
60
371

FIG. 68

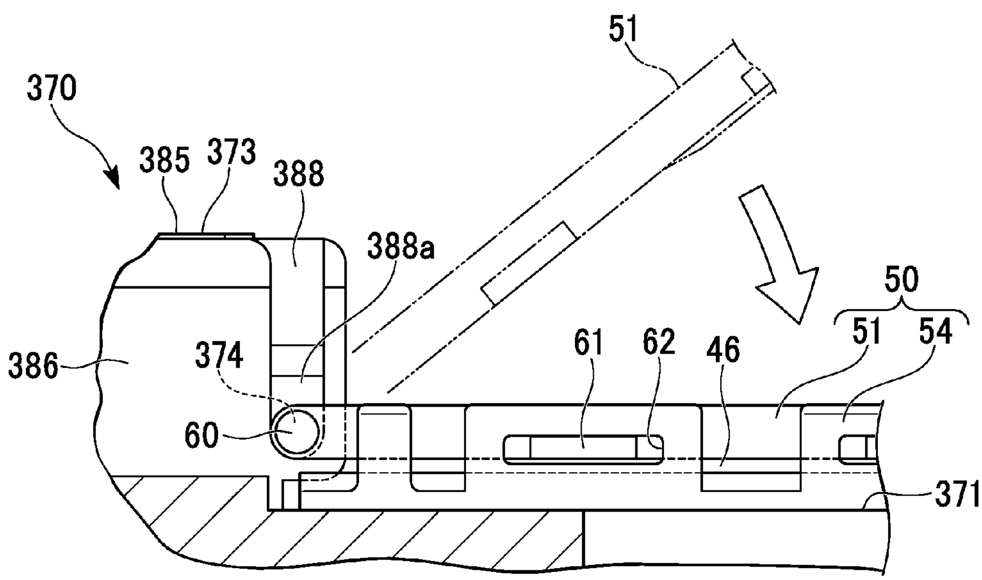

51
370
385
373
388
388a
50
51
54
61
62
46
386
374
60
371

FIG. 69

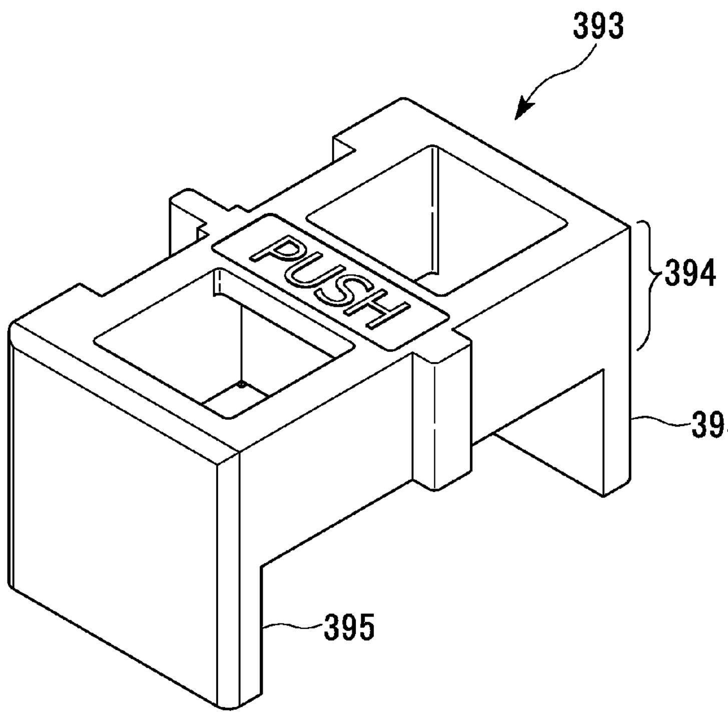


FIG. 70

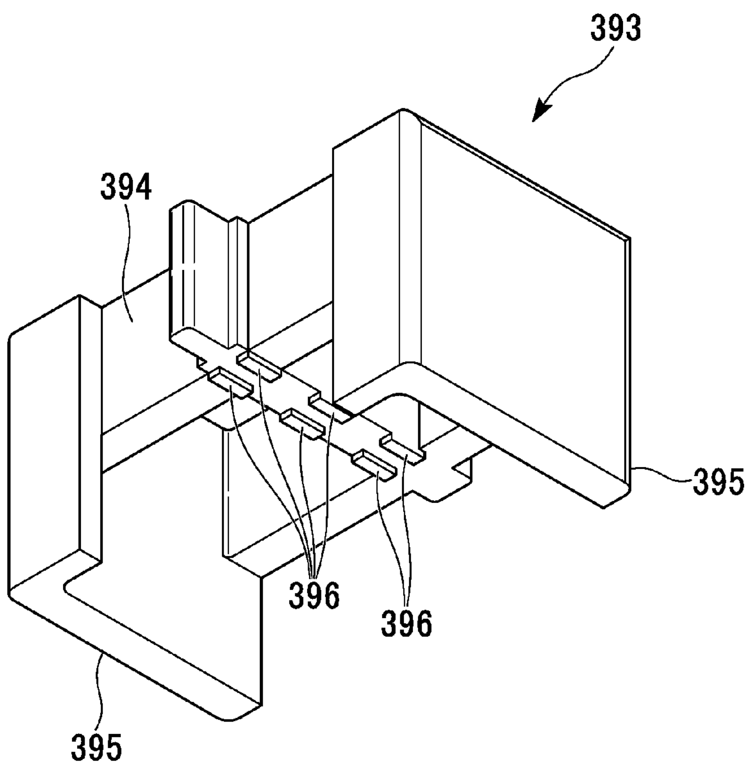
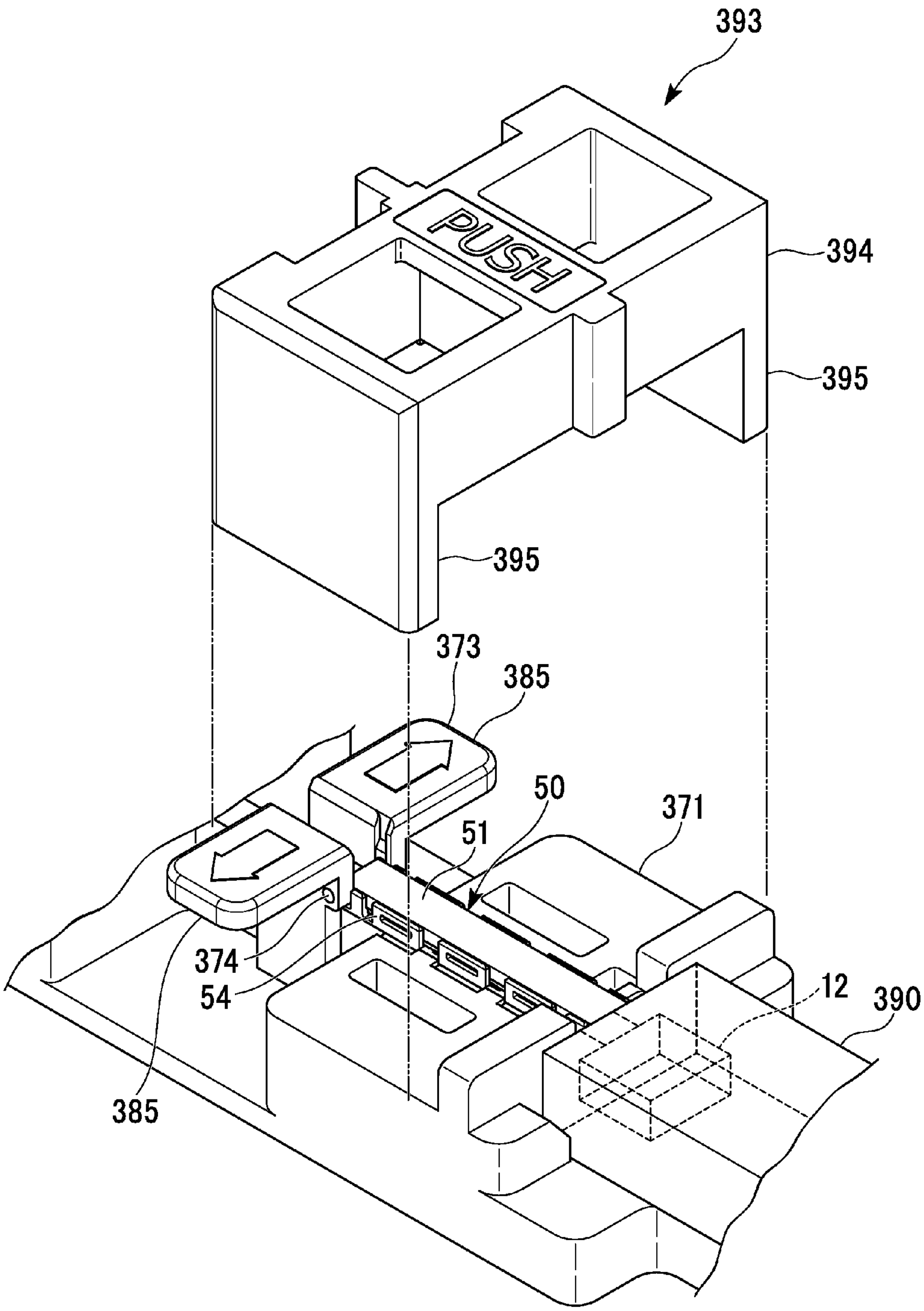


FIG. 71



OPTICAL FIBER CONNECTOR, OPTICAL FIBER CONNECTOR ASSEMBLING METHOD, FUSION-SPLICED PORTION REINFORCING METHOD, PIN CLAMP, CAP-ATTACHED OPTICAL FIBER CONNECTOR, OPTICAL FIBER CONNECTOR CAP, OPTICAL FIBER CONNECTOR ASSEMBLING TOOL, AND OPTICAL FIBER CONNECTOR ASSEMBLING SET

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a divisional application based on U.S. patent application Ser. No. 13/548,927, filed Jul. 13, 2012, which is a continuation based on a PCT Application No. PCT/JP2011/050560, filed Jan. 14, 2011, whose priority is claimed on Japanese Patent Application No. 2010-006290 filed Jan. 14, 2010, Japanese Patent Application No. 2010-006292 filed Jan. 14, 2010, and Japanese Patent Application No. 2010-006331 filed Jan. 14, 2010, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical fiber connector assembled to a front end portion of an optical transmission medium such as an optical fiber cord or an optical fiber cable and a method of assembling the optical fiber connector, and more particularly, to an optical fiber connector in which a front end portion of an optical transmission medium is optically connected to an optical fiber (short optical fiber) inserted into a ferrule by fusion splice between optical fibers, a method of assembling an optical fiber connector, a method of reinforcing a fusion-spliced portion of optical fibers which can be suitably used for the optical fiber connector, an optical fiber connector assembling tool, and an optical fiber connector assembling set.

The present invention also relates to an optical fiber connector assembled to a front end portion of an optical transmission medium such as an optical fiber cord or an optical fiber cable, a pin clamp used therein, and a method of assembling the optical fiber connector.

The present invention also relates to an optical fiber connector cap which is detachably attached to the housing of an optical fiber connector when assembling the optical fiber connector to a terminal of an optical transmission medium such as an optical fiber cord or an optical fiber cable in which an optical fiber and a fiber-like tensile member extending along the optical fiber is covered with a sheath and which is used for assembly work of the optical fiber connector.

2. Background Art

In the past, an optical fiber connector having built therein a mechanical splice mechanism interposing an inserted optical fiber, one end of which is fixed to a ferrule and an optical fiber of an external optical transmission medium, between two divided parts in a state where they are butt-jointed to each other and maintaining the butt-jointed state was known as an example of an optical fiber connector enabling a work of assembling an optical fiber connector to an end portion of an optical transmission medium such as an optical fiber cord or an optical fiber cable to be carried out on a splicing site (for example, see Japanese Unexamined Patent Application, First Publication No. 2002-196189).

An optical fiber connector connecting an optical fiber of an optical transmission medium and an optical fiber built in a ferrule of the optical fiber connector to each other by fusion was also known (for example, see U.S. Pat. No. 5,748,819 and Japanese Unexamined Patent Application, First Publication No. 2008-65315).

Japanese Unexamined Patent Application, First Publication No. 2002-196189 (particularly, paragraphs 0022 to 0024 and FIGS. 1 to 4) discloses an optical fiber connector precisely positioning optical fibers between two divided elements having an alignment groove (a V groove, a U groove, or the like) used to align optical fibers and butt-jointing the optical fibers.

U.S. Pat. No. 5,748,819 (particularly, FIGS. 1 to 3) discloses an optical fiber connector having a structure in which a fusion-spliced portion is disposed in a slot formed in a ferrule, a front end of a built-in optical fiber is located on an end face, and a rear end of the built-in optical fiber is exposed into the slot so as to be fusion-spliced to an end of an optical fiber of an optical transmission medium in the slot.

Japanese Unexamined Patent Application, First Publication No. 2008-65315 (particularly, paragraphs 0033 to 0036 and FIGS. 3 and 4) discloses an optical fiber connector in which an end of an optical fiber of which the other end is fixed to a ferrule is fusion-spliced to an end of an optical fiber core and the fusion-spliced portion is reinforced with a reinforcing member such as a heat-shrinkable sleeve or a metal sleeve.

An optical fiber connector configured to splice an inserted optical fiber of which an end portion is fixed to a ferrule and an optical fiber of an external optical transmission medium to each other by fusion or the like was known as an example of an optical fiber connector enabling a work of assembling an optical fiber connector to a front end portion of an optical transmission medium such as an optical fiber cord or an optical fiber cable to be carried out on a splicing site (for example, see Japanese Unexamined Patent Application, First Publication No. 2002-196189 and Japanese Unexamined Patent Application, First Publication No. H10-319275).

An example of such a type of optical fiber connector is a multi-core optical fiber connector (an MPO type optical fiber connector; MPO: Multi-fiber Push On) defined in the JIS C5982 or the like.

When butt-jointing the optical fiber connectors to each other, a guide pin protruding from a joint end face of a ferrule of one optical fiber connector is inserted into and locked to a guide pin insertion hole of a joint end face of a ferrule of the other optical fiber connector. Accordingly, the ferrules are positioned with a high precision.

One optical fiber connector is of a male type having a guide pin and the other optical fiber connector is of a female type not having a guide pin.

The guide pin is inserted into a guide pin insertion hole formed in the ferrule and then the rear end portion thereof is supported by a pin clamp formed in the back of the ferrule.

When assembling an optical fiber connector to an optical fiber cord terminal extending a tensile fiber has been carried out, which is longitudinally added to an optical fiber of an optical fiber cord and is received in a sheath along with the optical fiber, to a cord terminal and to fix the tensile fiber to the rear end of the body (housing) of the optical fiber connector with a metal ring by swaging so as to satisfactorily detain the optical fiber cord in the optical fiber connector (for example, see Japanese Unexamined Patent Application, First Publication No. 2001-235656).

The optical fiber connector disclosed in Japanese Unexamined Patent Application, First Publication No. 2002-196189 does not require an alignment groove to position optical fibers relative to each other before splicing. Accordingly, the decrease in cost is limited due to the presence of components to be machined by high-precision processing.

The optical fiber connector disclosed in U.S. Pat. No. 5,748,819 requires fusion work at a side surface position of a ferrule. Accordingly, when a general-purpose discharging electrode is used in the fusion work, the ferrule may be adversely affected and thus a general fusion splicer should not be used, thereby making the fusion work difficult.

In the optical fiber connector disclosed in Japanese Unexamined Patent Application, First Publication No. 2008-65315, the other end of the optical fiber fixed to the ferrule is drawn out from the ferrule, the adverse influence of the fusion work on the ferrule is reduced. However, since the reinforcing sleeve needs to pass the optical fiber core therethrough before the fusion work and to move to a position where it covers the outer circumference of the fusion-spliced portion after the fusion work, it takes much labor to form a splice reinforcing portion. The outer diameter of the optical fiber core needs to be smaller than the inner diameter of the sleeve (so that the outer circumferential shape of the sectional surface of the optical fiber core is included in the inner circumferential shape of the sectional surface of the sleeve). Accordingly, it is difficult to apply this technique to an optical transmission medium such as a drop cable or a multi-core optical fiber having a large outer diameter (outer circumferential shape).

In order to enhance the efficiency of the work on the splicing work site, there is a need for an optical fiber connector having a structure capable of selecting the presence or absence of a guide pin (male type or female type).

In the optical fiber connector, the guide pin can be attached and detached by inserting or pulling the guide pin, the rear end portion of which is fixed to a pin clamp, into or from the rear side thereof.

However, it is not possible to avoid the increase in size of the optical fiber connector, in that it is substantially difficult to attach and detach the guide pin in consideration of the adverse influence on an optical fiber spliced portion (for example, a fusion-spliced portion) and it is necessary to guarantee a space for movement of the pin clamp between the ferrule and the optical fiber spliced portion so as to avoid the adverse influence.

When the optical fiber connector is configured to weaken the fixing force in the rear end of the guide pin and to be able to easily insert or pull the guide pin into or from the front side of the ferrule, the space on the rear side of the ferrule is not necessary, but there is a problem in that the guide pin can easily fall out with this structure.

When performing the work of fixing the tensile fiber to the body of the optical fiber connector by swaging, it is necessary to swage a metal ring in a state where tension is applied to the tensile fiber. Accordingly, for example, as disclosed in Japanese Unexamined Patent Application, First Publication No. 2001-235656, a tool (hereinafter, also referred to as a swaging tool) capable of fixing the optical fiber connector and the optical fiber cord and fixing the tensile fiber extending from the cord terminal is necessary. The labor of fixing the optical fiber connector, the optical fiber cord, and the tensile fiber extending from the cord terminal by the use of the swaging tool is necessary.

SUMMARY OF THE INVENTION

The invention is made in consideration of the above-mentioned circumstances and has the following objects.

(1) An object of the invention is to provide an optical fiber connector and a method of assembling the optical fiber connector, which can facilitate the work of fusion-splicing optical fibers to each other and the work of reinforcing the fusion-spliced portion.

(2) Another object of the invention is to provide an optical fiber connector to and from which a guide pin can be attached and detached, which does not cause the guide pin to fall out, and which can suppress an increase in size, a pin clamp used therein, and a method of assembling the optical fiber connector.

(3) Still another object of the invention is to provide a cap-attached optical fiber connector which can simply perform the work of fixing a tensile member, which extends from the terminal of an optical transmission medium (an optical fiber cord or an optical fiber cable) in which an optical fiber and a fiber-like tensile member extending along the optical fiber are covered with a sheath, to a housing the optical fiber connector without using a tool for fixing the optical fiber connector, the optical fiber cord, the tensile member extending from the cord terminal and which can enhance the work efficiency of the connector assembling work, a method of assembling the optical fiber connector, and an optical fiber connector cap.

To achieve the above-mentioned objects, according to an aspect of the invention, there is provided an optical fiber connector including: a ferrule; an inserted optical fiber of which one end portion is fixed to the ferrule and of which the other end portion protrudes from the ferrule; an external optical fiber of which a front end portion is fusion-spliced to the other end portion of the inserted optical fiber; and a pair of reinforcing members that pinches and reinforces the fusion-spliced portion of the other end portion of the inserted optical fiber and the front end portion of the external optical fiber, wherein the reinforcing members include an adhesion layer on the inner surface thereof which comes in contact with the other end portion of the inserted optical fiber and the front end portion of the external optical fiber, and the adhesion layer is depressed at the position where the inserted optical fiber and the external optical fiber come in contact with each other so as to closely adhere to the outer circumferential surfaces of the optical fibers in the fusion-spliced portion.

The adhesion layer may be formed of rubber or an elastomer.

The adhesion layers of the pair of reinforcing members may closely adhere to each other at the position where the fusion-spliced portion is pinched between the pair of reinforcing members.

The pair of reinforcing members may include protuberance portions and recessed portions engaging with each other on both sides in the width direction perpendicular to the length direction of the inserted optical fiber and the external optical fiber, and the state where the adhesion layers of the pair of reinforcing members closely adhere to each other may be maintained by causing the protuberance portions and the recessed portions to engage with each other.

A ferrule boot covering the surrounding of the portion of the inserted optical fiber protruding from the ferrule may be attached to the ferrule, and the pair of reinforcing members may clamp the ferrule boot at end portions thereof close to the ferrule.

To achieve the above-mentioned objects, according to another aspect of the invention, there is provided a method of assembling an optical fiber connector, including the steps of: fusion-splicing the other end portion of an inserted optical fiber, of which one end portion is fixed to a ferrule and of which the other end portion protrudes from the ferrule, to a front end portion of an external optical fiber; and preparing a pair of reinforcing members including an adhesion layer, which can be depressed at the position where the inserted optical fiber and the external optical fiber come in contact with each other, on the inner surface thereof which comes in contact with the other end portion of the inserted optical fiber and the front end portion of the external optical fiber, pinching the fusion-spliced portion of the other end portion of the inserted optical fiber and the front end portion of the external optical fiber between the pair of reinforcing members, and causing the adhesion layers to closely adhere to the outer circumferential surfaces of the optical fibers in the fusion-spliced portion.

The adhesion layer may be formed of rubber or an elastomer.

When pinching the fusion-spliced portion between the pair of reinforcing members, the adhesion layers of the pair of reinforcing members may closely adhere to each other on both lateral sides of the optical fibers at the position where the fusion-spliced portion is pinched between the pair of reinforcing members.

The pair of reinforcing members may include protuberance portions and recessed portions engaging with each other on both sides in the width direction perpendicular to the length direction of the inserted optical fiber and the external optical fiber, and when pinching the fusion-spliced portion between the pair of reinforcing members, the pair of reinforcing members may be combined to maintain the state where the adhesion layers of the pair of reinforcing members closely adhere to each other by causing the protuberance portions and the recessed portions to engage with each other.

A ferrule to which a ferrule boot covering the surrounding of the portion of the inserted optical fiber protruding from the ferrule may be attached is used as the ferrule, and when pinching the fusion-spliced portion between the pair of reinforcing members, the ferrule boot may be clamped between the pair of reinforcing members at end portions of the pair of reinforcing members close to the ferrule.

A first reinforcing member having a shaft portion at an end portion opposite to the ferrule and a second reinforcing member opposed to the first reinforcing member may be used as the pair of reinforcing members, an assembling tool including a reinforcing member holding portion holding the second reinforcing member at a predetermined position and a bearing portion rotatably holding the shaft portion of the first reinforcing member when pinching the fusion-spliced portion between the pair of reinforcing members may be used. Before pinching the fusion-spliced portion between the pair of reinforcing members, a step of holding the second reinforcing member on the reinforcing member holding portion, a step of placing the fusion-spliced portion on the second reinforcing member, a step of holding the shaft portion of the first reinforcing member on the bearing portion, and a step of rotating the first reinforcing member toward the second reinforcing member about the shaft portion in the bearing portion until the fusion-spliced portion is pinched between the first reinforcing member and the second reinforcing member may be performed.

According to still another aspect of the invention, there is provided a reinforcement method of pinching and reinforcing a fusion-spliced portion, in which end portions of a first optical fiber and a second optical fiber are fusion-spliced to each other, between a pair of reinforcing members, including the steps of: preparing a first reinforcing member having a shaft portion at an end in the length direction of the first optical fiber and the second optical fiber and a second reinforcing member opposed to the first reinforcing member as a pair of reinforcing members including an adhesion layer, which can be depressed at a position where the first optical fiber and the second optical fiber come in contact with each other, on the inner surface which comes in contact with the first optical fiber and the second optical fiber; preparing an assembling tool including a reinforcing member holding portion holding the second reinforcing member at a predetermined position and a bearing portion rotatably holding the shaft portion of the first reinforcing member when pinching the fusion-spliced portion between the pair of reinforcing members; holding the second reinforcing member on the reinforcing member holding portion; placing the fusion-spliced portion on the second reinforcing member; holding the shaft portion of the first reinforcing member on the bearing portion; rotating the first reinforcing member toward the second reinforcing member about the shaft portion in the bearing portion until the fusion-spliced portion is pinched between the first reinforcing member and the second reinforcing member, and interposing the fusion-spliced portion between the pair of reinforcing members and causing the adhesion layers to closely adhere to the outer circumferential surface of the optical fibers in the fusion-spliced portion.

The adhesion layer may be formed of rubber or an elastomer.

When pinching the fusion-spliced portion between the pair of reinforcing members, the adhesion layers of the pair of reinforcing members may closely adhere to each other on both lateral sides of the optical fibers at the position where the fusion-spliced portion is pinched between the pair of reinforcing members.

The pair of reinforcing members may include protuberance portions and recessed portions engaging with each other on both sides in the width direction perpendicular to the length direction of the first optical fiber and the second optical fiber, and when pinching the fusion-spliced portion between the pair of reinforcing members, the pair of reinforcing members may be combined to maintain the state where the adhesion layers of the pair of reinforcing members closely adhere to each other by causing the protuberance portions and the recessed portions to engage with each other.

According to still another aspect of the invention, there is provided an optical fiber connector including: a ferrule that has a guide pin insertion hole into which a positioning guide pin of an opposite optical fiber connector can be inserted so as to be pulled out therefrom; an optical fiber of which one end portion reaching a joint end face of the ferrule is fixed to the ferrule and of which the other end portion extends from the ferrule; and a pin clamp that can be attached to a protrusion protruding from the opposite side to the joint end face of the ferrule in the guide pin inserted into the guide pin insertion hole so as to be detached therefrom in the direction crossing the guide pin insertion hole, wherein the pin clamp includes a fitting recessed portion that is fitted to the protruding portion of the guide pin to regulate the movement in the length direction of the guide pin, and the fitting recessed portion is formed to receive and put out the protrusion of the guide pin in the direction crossing the guide pin insertion hole.

The protrusion of the guide pin may have a large-diameter portion and a small-diameter portion having a diameter smaller than that of the large-diameter portion at the tip thereof, and the fitting recessed portion may be locked to the small-diameter portion to regulate the movement of the large-diameter portion toward the tip.

The ferrule may have two guide pin insertion holes, which are formed on both sides with the optical fiber pinched therebetween, the pin clamp may have a bottom portion and side wall portions formed on both sides thereof and a space surrounded with the bottom portion and the side wall portions on both sides thereof serves as an insertion space of the optical fiber, and the pin clamp may have two fitting recessed portions, which are formed in the side wall portions on both sides.

The optical fiber may be an inserted optical fiber, the other end portion of the inserted optical fiber may be spliced to an external optical fiber, a ferrule boot covering a portion of the inserted optical fiber extending from the ferrule may be attached to the portion, and the pin clamp may be formed to insert the ferrule boot into the insertion space.

A holding protrusion that protrudes to the inside and that regulates the movement of the ferrule boot in the insertion space to the outside may be formed in the side wall portions of the pin clamp.

According to still another aspect of the invention, there is provided a pin clamp used for an optical fiber connector including a ferrule that has a guide pin insertion hole into which a positioning guide pin of an opposite optical fiber connector can be inserted so as to be pulled out therefrom and an optical fiber of which one end portion reaching a joint end face of the ferrule is fixed to the ferrule and of which the other end portion extends from the ferrule, wherein the pin clamp can be attached to a protrusion protruding from the opposite side to the joint end face of the ferrule in the guide pin inserted into the guide pin insertion hole so as to be detached therefrom in the direction crossing the guide pin insertion hole, wherein the pin clamp includes a fitting recessed portion that is fitted to the protruding portion of the guide pin to regulate the movement in the length direction of the guide pin, and wherein the fitting recessed portion is formed to receive and put out the protrusion of the guide pin in the direction crossing the guide pin insertion hole.

According to still another aspect of the invention, there is provided a method of assembling an optical fiber connector including a ferrule that has a guide pin insertion hole into which a positioning guide pin of an opposite optical fiber connector can be inserted so as to be pulled out therefrom, an optical fiber of which one end portion reaching a joint end face of the ferrule is fixed to the ferrule and of which the other end portion extends from the ferrule, and a pin clamp that can be attached to a protrusion protruding from the opposite side to the joint end face of the ferrule in the guide pin inserted into the guide pin insertion hole so as to be detached therefrom in the direction crossing the guide pin insertion hole, wherein the pin clamp includes a fitting recessed portion that is fitted to the protruding portion of the guide pin to regulate the movement in the length direction of the guide pin, and the fitting recessed portion is formed to receive and put out the protrusion of the guide pin in the direction crossing the guide pin insertion hole, the method including the steps of: splicing the other end portion of the optical fiber to a front end portion of an external optical fiber; and attaching the pin clamp to the protrusion of the guide pin so that the protrusion of the guide pin is locked to the fitting recessed portion from the direction crossing the guide pin insertion hole.

According to still another aspect of the invention, there is provided a cap-attached optical fiber connector including: an optical fiber connector that is assembled (coupled) to a terminal of an optical transmission medium in which an optical fiber and a fiber-like tensile member extending along the optical fiber are covered with a sheath; and an optical fiber connector cap that is detachably attached to a front end portion which is an end portion of the optical fiber connector, wherein the optical fiber connector includes a ferrule, a housing having a sleeve shape for receiving the ferrule and having a ring member fixing portion fixing a ring member on the outer circumference thereof, and an inserted optical fiber which is inserted into and fixed to the ferrule and of which a portion extending rearward from the ferrule is optically connected to an optical fiber drawn out of the terminal of the optical transmission medium, wherein a tensile member detaining portion detaining the tensile member of the optical transmission medium is provided to the outer surface of the body of the optical fiber connector cap, and wherein the tensile member can be fixed to the housing by fixing the ring member to the ring member fixing portion in a state where the tensile member extending forward through the vicinity of the ring member fixing portion from the terminal of the optical transmission medium is detained in the tensile member detaining portion.

According to still another aspect of the invention, there is provide a cap-attached optical fiber connector including: an optical fiber connector that is assembled to a terminal of an optical transmission medium in which an optical fiber and a fiber-like tensile member extending along the optical fiber are covered with a sheath; and an optical fiber connector cap that is detachably attached to a front end portion which is an end portion of the optical fiber connector, wherein the optical fiber connector includes a ferrule into and to which an optical fiber drawn out of the terminal of the optical transmission medium is inserted and fixed and a housing having a sleeve shape for receiving the ferrule and having a ring member fixing portion fixing a ring member on the outer circumference thereof, wherein a tensile member detaining portion detaining the tensile member of the optical transmission medium is provided to the outer surface of the body of the optical fiber connector cap, and wherein the tensile member can be fixed to the housing by fixing the ring member to the ring member fixing portion in a state where the tensile member extending forward through the vicinity of the ring member fixing portion from the terminal of the optical transmission medium is detained in the tensile member detaining portion.

The ring member fixing portion may be a screw portion to which a screwed ring member can be screwed, and the tensile member may be fixed to the housing by screwing the screwed ring member to the screw portion in a state where the tensile member extending forward through the vicinity of the screw portion from the terminal of the optical transmission medium is detained in the tensile member detaining portion.

The ring member fixing portion may be a swage ring attachment portion to which a swage ring can be fixed by swaging, and the tensile member may be fixed to the housing by fixing the swage ring to the swage ring attachment portion in a state where the tensile member extending forward through the vicinity of the swage ring attachment portion from the terminal of the optical transmission medium is detained in the tensile member detaining portion.

The tensile member detaining portion of the optical fiber connector cap may be a hooking protrusion protruding from the outer surface of the body of the optical fiber connector cap and capable of hooking and detaining the tensile member.

The ferrule may be a multi-core ferrule of a pin-fitting positioning type which is positioned and butt-jointed by locking a pair of guide pins protruding from an end face of one of the ferrule and an opposite ferrule butt-jointed thereto to a pair of guide pin holes formed in the end face of the other and a plurality of the inserted optical fibers may be inserted into and fixed to the ferrule.

According to still another aspect of the invention, there is provided a method of assembling an optical fiber connector to a terminal of an optical transmission medium in which an optical fiber and a fiber-like tensile member extending along the optical fiber are covered with a sheath, including: a fiber connecting step of optically connecting the optical fiber drawn out of the terminal of the optical transmission medium to a rear extension which is a portion extending backward from a ferrule of an inserted optical fiber inserted into and fixed to the ferrule; a housing assembling step of assembling a housing of the optical fiber connector to the front side of the terminal of the optical transmission medium and receiving a spliced portion of the inserted optical fiber and the optical fiber of the optical transmission medium and the ferrule after the fiber connecting step; and a tensile member fixing step of detaining a tensile member extending forward through the vicinity of a ring member fixing portion formed on the outer circumference of the housing from the terminal of the optical transmission medium in a tensile member detaining portion formed on the outer surface of a body of an optical fiber connector cap in a state where the optical fiber connector cap is detachably attached to a front end portion of the housing and then fixing the tensile member to the housing by fixing a ring member to the ring member fixing portion.

The ring member fixing portion may be a screw portion to which a screwed ring member can be screwed, and the tensile member fixing step may include fixing the tensile member to the housing by screwing the screwed ring member to the screw portion in a state where the tensile member extending forward through the vicinity of the screw portion from the terminal of the optical transmission medium is detained in the tensile member detaining portion.

The ring member fixing portion may be a swage ring attachment portion to which a swage ring can be fixed by swaging, and the tensile member fixing step may include fixing the tensile member to the housing by fixing the swage ring to the swage ring attachment portion in a state where the tensile member extending forward through the vicinity of the swage ring attachment portion from the terminal of the optical transmission medium is detained in the tensile member detaining portion.

The tensile member detaining portion of the optical fiber connector cap may be a hooking protrusion protruding from the outer surface of the body of the optical fiber connector cap and capable of hooking and detaining the tensile member.

The fiber connecting step may include a fusion-splicing and reinforcing step of fusion-splicing the inserted optical fiber and the optical fiber of the optical transmission medium to each other and then reinforcing the fusion-spliced portion by the use of a reinforcing member.

The fusion-splicing and reinforcing step may include fusion-splicing the inserted optical fiber and the optical fiber of the optical transmission medium to each other, then pinching the fusion-spliced portion between a pair of pinch members, which is used as the reinforcing member, each having an adhesion layer which can be depressed at a position where the inserted optical fiber and the optical fiber of the optical transmission medium on the inner surface which comes in contact with a rear extension of the inserted optical fiber and the optical fiber of the optical transmission medium, and closely adhering the adhesion layers to the outer circumferential surfaces of the optical fibers in the fusion-spliced portion.

The pair of pinch members may include pinching engagement portions that pinch the fusion-spliced portion by engaging with each other and that maintain a pressing force for closely adhering the adhesion layers to the outer circumferential surfaces in the fusion-spliced portion the inserted optical fiber and the optical fiber of the optical transmission medium.

The adhesion layers may be formed of rubber or elastomer.

The ferrule may be a multi-core ferrule of a pin-fitting positioning type which is positioned and butt-jointed by locking a pair of guide pins protruding from an end face of one of the ferrule and an opposite ferrule butt-jointed thereto to a pair of guide pin holes formed in the end face of the other and a plurality of the inserted optical fibers are inserted into and fixed to the ferrule.

According to still another aspect of the invention, there is provided an optical fiber connector cap which is detachably attached to an end portion of an optical fiber connector and in which a tensile member detaining portion that fixes a tensile member extending from a terminal of an optical transmission medium when assembling the optical fiber connector to the terminal of the optical transmission medium in which an optical fiber and a fiber-like tensile member extending along the optical fiber are covered with a sheath is provided to the outer surface of the optical fiber connector cap.

The tensile member detaining portion may be a hooking protrusion capable of hooking and detaining the tensile member.

According to still another aspect of the invention, there is provided an optical fiber connector assembling tool used to assemble an optical fiber connector, the optical fiber connector including a ferrule, an inserted optical fiber of which one end portion is fixed to the ferrule and of which the other end portion protrudes from the ferrule, an external optical fiber of which a front end portion is fusion-spliced to the other end portion of the inserted optical fiber, and a pair of reinforcing members that pinches and reinforces the fusion-spliced portion of the other end portion of the inserted optical fiber and the front end portion of the external optical fiber, the pair of reinforcing members including a first reinforcing member having a shaft portion at an end opposite to the ferrule and a second reinforcing member opposed to the first reinforcing member, the optical fiber connector assembling tool including a bearing supporting portion which includes a reinforcing member holding portion holding the second reinforcing member at a predetermined position and a bearing portion rotatably holding the shaft portion of the first reinforcing member, wherein the bearing supporting portion enables the first reinforcing member to rotationally move toward the second reinforcing member held by the reinforcing member holding portion until the first reinforcing members pinch the fusion-spliced portion.

The optical fiber connector assembling tool may further include: a core holding portion that holds the external optical fiber; and a pressing cover that presses the external optical fiber on the core holding portion.

The shaft portion may protrude to one side and the other side of the first reinforcing member, the bearing supporting portion may include a pair of support members opposed to each other, and the bearing portion may be formed in each of the pair of support members and supports the shaft portion protruding on one side and the other side of the first reinforcing member.

According to still another aspect of the invention, there is provided an optical fiber connector assembling set including the above-mentioned optical fiber connector assembling tool and the optical fiber connector.

According to still another aspect of the invention, there is provided a method of assembling an optical fiber connector using the above-mentioned optical fiber connector assembling tool, including: before pinching the fusion-spliced portion between the pair of reinforcing members, a step of holding the second reinforcing member on the reinforcing member holding portion, a step of placing the fusion-spliced portion on the second reinforcing member, a step of holding the shaft portion of the first reinforcing member on the bearing portion, and a step of rotating the first reinforcing member toward the second reinforcing member about the shaft portion in the bearing portion until the fusion-spliced portion is pinched between the first reinforcing member and the second reinforcing member.

An optical fiber connector of the invention includes: a ferrule; an inserted optical fiber of which one end portion is fixed to the ferrule and an other end portion protrudes from the ferrule; an external optical fiber of which a front end portion is fusion-spliced to the other end portion of the inserted optical fiber; and one or more reinforcing members that reinforce the fusion-spliced portion of the other end portion of the inserted optical fiber and the front end portion of the external optical fiber

It is preferable that the optical fiber connector of the invention further include an adhesion layer applied on the inner surface of the reinforcing members. The adhesion layer covers an area where the inserted optical fiber and the external optical fiber come in contact with each other, and adheres to the outer surfaces of the other end portion of the inserted optical fiber and the front end portion of the external optical fiber.

In the optical fiber connector of the invention, it is preferable that the adhesion layer include rubber or an elastomer.

In the optical fiber connector of the invention, it is preferable that the one or more reinforcing members include a pair of reinforcing members having protuberance portions and recessed portions engaging with each other. The adhesion layer maintains the engaging of the protuberance portions and the recessed portions with each other.

It is preferable that the optical fiber connector of the invention further include a ferrule boot which covers the surrounding of the other end portion of the inserted optical fiber. The ferrule boot is attached to the ferrule. The one or more reinforcing members further secure the ferrule boot to the ferrule.

A method of assembling an optical fiber connector of the invention, includes: fusion-splicing an other end portion of an inserted optical fiber to a front end portion of an external optical fiber, one end portion of the inserted optical fiber being fixed to a ferrule and the other end portion being protruded from the ferrule; and applying one or more reinforcing members to secure the fusion-spliced portion of the other end portion of the inserted optical fiber and the front end portion of the external optical fiber to the ferrule.

It is preferable that the method of assembling an optical fiber connector of the invention further include applying an adhesion layer on the inner surface of the reinforcing members. The adhesion layer covers an area where the inserted optical fiber and the external optical fiber come in contact with each other, and adheres to the outer surfaces of the other end portion of the inserted optical fiber and the front end portion of the external optical fiber.

In the method of assembling an optical fiber connector of the invention, it is preferable that the adhesion layer include rubber or an elastomer.

In the method of assembling an optical fiber connector of the invention, it is preferable that the one or more reinforcing members include a pair of reinforcing members having protuberance portions and recessed portions engaging with each other. The adhesion layer maintains the engaging of the protuberance portions and the recessed portions with each other.

It is preferable that the method of assembling an optical fiber connector of the invention further include applying a ferrule boot to cover the surrounding of the other end portion of the inserted optical fiber, the ferrule boot being attached to the ferrule. The ferrule boot is secured to the ferrule by the one or more reinforcing members.

In the method of assembling an optical fiber connector of the invention, it is preferable that the one or more reinforcing members include a first reinforcing member having a shaft portion and a second reinforcing member. The securing of the fusion-spliced portion between the first and second reinforcing members is performed using an assembling tool including a reinforcing member holding portion and a bearing portion. The method includes: holding the second reinforcing member on the reinforcing member holding portion at a predetermined position, placing the fusion-spliced portion on the second reinforcing member, holding the shaft portion of the first reinforcing member on the bearing portion, and rotating the first reinforcing member toward the second reinforcing member about the shaft portion in the bearing portion until the fusion-spliced portion is pinched between the first reinforcing member and the second reinforcing member.

It is preferable that the method of assembling an optical fiber connector of the invention further include arranging the first reinforcing member having the shaft portion at an end in the length direction of the inserted optical fiber and the external optical fiber; arranging the second reinforcing member opposed to the first reinforcing member as a pair of reinforcing members; and applying an adhesion layer on the inner surface of the pair of reinforcing members, covering an area where the inserted optical fiber and the external optical fiber come in contact with each other, and adhering to the outer surfaces of the other end portion of the inserted optical fiber and the front end portion of the external optical fiber.

It is preferable that the method of assembling an optical fiber connector of the invention further include interposing the fusion-spliced portion between the pair of reinforcing members to cause the adhesion layer to adhere to the outer circumferential surface of the inserted and external optical fibers in the fusion-spliced portion.

A pin clamp used of the invention for an optical fiber connector includes a ferrule that has a guide pin insertion hole being formed to receive a positioning guide pin of an opposite optical fiber connector and an optical fiber of which one end portion reaching a joint end face of the ferrule is fixed to the ferrule and of which an other end portion extends from the ferrule. The pin clamp, which can be attached to a protrusion protruding from the opposite side to the joint end face of the ferrule, is formed to secure the positioning guide pin in the guide pin insertion hole, and can be detached from the ferrule in the direction crossing the guide pin insertion hole The pin clamp includes a fitting recessed portion being formed to fit the protruding portion of the positioning guide pin to regulate the movement in the length direction of the positioning guide pin. The fitting recessed portion is formed to receive the protrusion of the guide pin in the direction crossing the guide pin insertion hole.

A method of assembling an optical fiber connector of the invention including a ferrule that has a guide pin insertion hole being formed to receive a positioning guide pin of an opposite optical fiber connector, an optical fiber of which one end portion reaching a joint end face of the ferrule is fixed to the ferrule and of which an other end portion extends from the ferrule, and a pin clamp that can be attached to a protrusion protruding from the opposite side to the joint end face of the ferrule being formed to secure the guide pin in the guide pin insertion hole, and can be detached from the ferrule in the direction crossing the guide pin insertion hole, the pin clamp includes a fitting recessed portion being formed to fit the protruding portion of the guide pin to regulate the movement in the length direction of the guide pin, and the fitting recessed portion being formed to receive and put out the protrusion of the guide pin in the direction crossing the guide pin insertion hole. The method includes the steps of: splicing the other end portion of the optical fiber to a front end portion of an external optical fiber; and attaching the pin clamp to the protrusion of the guide pin so that the protrusion of the guide pin is locked to the fitting recessed portion from the direction crossing the guide pin insertion hole.

An optical fiber connector of the invention includes: a ferrule that has a guide pin insertion hole being formed to receive a positioning guide pin of an opposite optical fiber connector; an optical fiber of which one end portion reaching a joint end face of the ferrule is fixed to the ferrule and of which an other end portion extends from the ferrule; and a pin clamp that can be attached to a protrusion protruding from the opposite side to the joint end face of the ferrule being formed to secure the positioning guide pin in the guide pin insertion hole, and can be detached from the ferrule in the direction crossing the guide pin insertion hole. The pin clamp includes a fitting recessed portion is formed to fit the protruding portion of the positioning guide pin to regulate the movement in the length direction of the positioning guide pin. The fitting recessed portion is formed to receive the protrusion of the guide pin in the direction crossing the guide pin insertion hole.

In the optical fiber connector of the invention, it is preferable that the fitting recessed portion is formed to receive the protrusion of the guide pin that has a large-diameter portion and a small-diameter portion having a diameter smaller than that of the large-diameter portion at the tip thereof. The fitting recessed portion is locked to the small-diameter portion to regulate the movement of the large-diameter portion toward the tip.

In the optical fiber connector of the invention, it is preferable that the ferrule have two guide pin insertion holes including the guide pin insertion hole, and the two guide pin insertion holes be formed on both sides with the optical fiber pinched there between, The pin clamp has a bottom portion and side wall portions formed on both sides thereof and a space surrounded with the bottom portion and the side wall portions on both sides thereof serves as an insertion space of the optical fiber. The pin clamp has two fitting recessed portions, which are formed in the side wall portions on both sides.

An optical fiber connector cap of the invention which is detachably attached to an end portion of an optical fiber connector and in which a tensile member detaining portion that fixes a tensile member extending from a terminal of an optical transmission medium when assembling the optical fiber connector to the terminal of the optical transmission medium in which an optical fiber and a fiber-like tensile member extending along the optical fiber are covered with a sheath is provided to the outer surface of the optical fiber connector cap.

In the optical fiber connector cap of the invention, it is preferable that the tensile member detaining portion include a hooking protrusion capable of hooking and detaining the tensile member.

An optical fiber connector assembling tool of the invention includes: a bearing supporting portion which includes a reinforcing member holding portion being formed to hold a second reinforcing member at a predetermined position, and a bearing portion being formed to rotatably hold a shaft portion of a first reinforcing member. The bearing portion enables the first reinforcing member to rotationally move toward the second reinforcing member held by the reinforcing member holding portion until the first reinforcing member pinch the fusion-spliced portion. The shaft portion of the first reinforcing member is positioned at an end opposite to a ferrule, and the second reinforcing member being opposed to the first reinforcing member. The ferrule is part of an optical fiber connector having an inserted optical fiber of which one end portion is fixed to the ferrule and an other end portion protrudes from the ferrule, and has an external optical fiber of which a front end portion is fusion-spliced to the other end portion of the inserted optical fiber. The first and second reinforcing members pinch and reinforce the fusion-spliced portion of the other end portion of the inserted optical fiber and the front end portion of the external optical fiber.

A method of assembling an optical fiber connector using the above-described optical fiber connector assembling tool, includes: before pinching the fusion-spliced portion between the first and second reinforcing members, holding the second reinforcing member on the reinforcing member holding portion, placing the fusion-spliced portion on the second reinforcing member, holding the shaft portion of the first reinforcing member on the bearing portion, and rotating the first reinforcing member toward the second reinforcing member about the shaft portion in the bearing portion until the fusion-spliced portion is pinched between the first reinforcing member and the second reinforcing member.

Advantageous Effects of the Invention

According to the invention, after one end portion of an inserted optical fiber of which the other end is fixed to the ferrule and an end portion of an external optical fiber are fusion-spliced to each other outside the ferrule, the fusion-spliced portion can be pinched and maintained between a pair of reinforcing members and it is not necessary to pass the external optical fiber through the reinforcing members before the fusion splicing, thereby facilitating the work of fusion-splicing the optical fibers and the work of reinforcing the fusion-spliced portion. Since the adhesion layers that are depressed by the contact with the optical fibers to closely adhere to the outer circumferential surfaces are provided to the inner surface of the reinforcing members, it is not necessary to provide a mechanism such as a V groove or a U groove for aligning the optical fibers to the inner surfaces of the reinforcing members.

According to the invention, since the pin clamp includes the fitting recessed portion receiving and putting out the protrusion of the guide pin in the direction crossing the guide pin insertion hole, it is possible to release the movement regulation in the length direction of the guide pin and to detach the guide pin, by moving the pin clamp in the direction.

Accordingly, the shape (male form) having a guide pin and the shape (female form) not having a guide pin can be easily switched to each other, thereby improving the workability on the splicing site.

Since it is not necessary to move the pin clamp backward when detaching the guide pin, the spliced portion of the optical fibers is not adversely influenced. Accordingly, since it is not necessary to guarantee a space for movement of the pin clamp between the ferrule and the spliced portion, it is possible to reduce the size of the optical fiber connector in the length direction.

Since the pin clamp includes the fitting recessed portion to which the protrusion of the guide pin is locked, it is possible to prevent the guide pin from falling out toward the front end.

According to the invention, in the work of assembling an optical fiber connector to a terminal of an optical transmission medium, a tensile member extending from the terminal of the optical transmission medium can be detained in the tensile member detaining portion of an optical fiber connector cap attached to the housing of the optical fiber connector. Accordingly, it is possible to simply achieve a state where tension acts on the tensile member extending from the terminal of the optical transmission medium, by only detaining the tensile member extending from the terminal of the optical transmission medium in the tensile member detaining portion of the optical fiber connector cap without using a tool for fixing an optical fiber connector, an optical fiber cord, and a tensile member extending from a terminal of the cord as in the background art. As a result, it is possible to reduce the labor for the work of assembling the optical fiber connector to the terminal of the optical transmission medium and to improve the work efficiency of the assembling work.

Since the optical fiber connector cap has a constitution simpler than that of the swaging tool in the background art and is available at a cost lower than that of the swaging tool, it is possible to reduce the cost for assembling the optical fiber connector.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a sectional view illustrating an optical fiber connector according to a first embodiment of the invention and is a sectional view taken along a plane in which a multi-core optical fiber is arranged.

FIG. **1**B is a sectional view illustrating the optical fiber connector shown in FIG. **1**A and is a sectional view taken along a plane perpendicular to the plane shown in FIG. **1**A and parallel to the length direction of the optical fiber.

FIG. **2**A is a sectional view illustrating a ferrule and a slice reinforcing portion of the optical fiber connector shown in FIGS. **1**A and **1**B and is a sectional view taken along the plane in which the multi-core optical fiber is arranged.

FIG. **2**B is a sectional view illustrating the ferrule and the slice reinforcing portion of the optical fiber connector shown in FIGS. **1**A and **1**B and is a sectional view taken along a plane perpendicular to the plane shown in FIG. **2**A and parallel to the length direction of the optical fiber.

FIG. **3** is a plan view illustrating an inserted optical fiber and an external optical fiber of the optical fiber connector shown in FIGS. **1**A and **1**B.

FIG. **4**A is a perspective view illustrating a first reinforcing member of the slice reinforcing portion shown in FIGS. **2**A and **2**B.

FIG. **4**B is a perspective view illustrating a second reinforcing member of the slice reinforcing portion shown in FIGS. **2**A and **2**B.

FIG. **5** is a side view illustrating a state where the first reinforcing member and the second reinforcing member shown in FIGS. **4**A and **4**B are opposed to each other with a gap therebetween.

FIG. **6** is a side view illustrating a state where the first reinforcing member and the second reinforcing member shown in FIGS. **4**A and **4**B are combined.

FIG. **7** is a sectional view taken along line S-S of FIG. **6**.

FIG. **8** is a schematic diagram illustrating an example of a state where the second reinforcing member is placed on an assembling tool.

FIG. **9** is a schematic diagram illustrating an example of a state where a fusion-sliced portion is placed on the second reinforcing member.

FIG. **10** is a schematic diagram illustrating an example of a state where a shaft portion of the first reinforcing member is held in a bearing portion of the assembling tool.

FIG. **11** is a schematic diagram illustrating an example of a state where a pressing cover of the assembling tool is closed.

FIG. **12** is a schematic diagram illustrating an example of a state where the fusion-sliced portion is held between the first reinforcing member and the second reinforcing member.

FIG. **13** is a schematic diagram illustrating an example of a state where the slice reinforcing portion is detached from the assembling tool.

FIG. **14** is a schematic diagram illustrating an example of a state where the fusion-sliced portion is held between the first reinforcing member and the second reinforcing member using the assembling tool having a pressing cover on both sides of the reinforcing members.

FIG. **15** is a schematic diagram illustrating an example of a state where the slice reinforcing portion assembled using the assembling tool having a pressing cover on both sides of the reinforcing members is detached from the assembling tool.

FIG. **16** is a sectional view illustrating a state where an optical fiber is held in the slice reinforcing portion.

FIG. **17**A is a sectional view illustrating a modification of the optical fiber connector according to the invention and is a sectional view taken along the plane in which a multi-core optical fiber is arranged.

FIG. **17**B is a sectional view illustrating a modification of the optical fiber connector shown in FIG. **17**A and is a sectional view taken along a plane perpendicular to the plane shown in FIG. **17**A and parallel to the length direction of the optical fiber.

FIG. **18** is a perspective view illustrating a ferrule and a pin clamp of an optical fiber connector according to a second embodiment of the invention.

FIG. **19** is a perspective view illustrating the pin clamp shown in FIG. **18**.

FIG. **20** is a plan view illustrating the pin clamp shown in FIG. **18**.

FIG. **21** is a front view illustrating the pin clamp shown in FIG. **18**.

FIG. **22** is a perspective view illustrating the guide pin shown in FIG. **18**.

FIG. **23**A is a sectional view illustrating an optical fiber connector and is a sectional view taken along a plane in which a multi-core optical fiber is arranged.

FIG. **23**B is a sectional view illustrating the optical fiber connector shown in FIG. **23**A and is a sectional view taken along a plane perpendicular to the plane shown in FIG. **23**A and parallel to the length direction of the optical fiber.

FIG. **24**A is a sectional view illustrating a ferrule and a slice reinforcing portion of the optical fiber connector shown in FIGS. **23**A and **23**B and is a sectional view taken along the plane in which the multi-core optical fiber is arranged.

FIG. **24**B is a sectional view illustrating the ferrule and the slice reinforcing portion of the optical fiber connector shown in FIGS. **23**A and **23**B and is a sectional view taken along a plane perpendicular to the plane shown in FIG. **24**A and parallel to the length direction of the optical fiber.

FIG. **25** is a plan view illustrating an inserted optical fiber and an external optical fiber of the optical fiber connector.

FIG. **26** is a diagram illustrating a usage of a pin clamp.

FIG. **27** is a diagram illustrating a usage of the pin clamp.

FIG. **28** is a diagram illustrating a usage of the pin clamp.

FIG. **29** is a diagram illustrating another example of the pin clamp.

FIG. **30** is a front view illustrating the pin clamp shown in FIG. **29**.

FIG. **31** is a sectional view illustrating an optical fiber connector and a cap-attached optical fiber connector according to a third embodiment of the invention.

FIG. **32**A is a diagram illustrating a method of assembling the optical fiber connector shown in FIG. **31**.

FIG. **32**B is a diagram illustrating the optical fiber connector assembling method subsequent to FIG. **32**A.

FIG. **33** is a perspective view illustrating an example of a structure of an optical fiber cord applicable to the invention.

FIG. **34** is a diagram illustrating an example where a loop to be hooked to a hooking protrusion of an optical fiber connector cap is formed in a tensile fiber bundle extending from the optical fiber cord shown in FIG. **33**.

FIG. **35** is a diagram illustrating a fiber connecting step in an optical fiber connector assembling method according to the first embodiment.

FIG. **36** is a sectional perspective view illustrating the structure of an example of a reinforcing sleeve which can be suitably used in the fiber connecting step (fusion-slicing and reinforcing step) of the optical fiber connector assembling method according to the first embodiment.

FIG. **37** is a diagram illustrating the fiber connecting step (fusion-slicing and reinforcing step) using the reinforcing sleeve shown in FIG. **36**.

FIG. **38** is a sectional view illustrating an optical fiber connector obtained by assembling a cap to the optical fiber connector shown in FIG. **31**.

FIG. **39** is a sectional view illustrating the optical fiber connector and the cap-attached optical fiber connector according to the first embodiment of the invention.

FIG. **40**A is a diagram illustrating an optical fiber connector assembling method according to a fourth embodiment of the invention.

FIG. **40**B is a diagram illustrating the optical fiber connector assembling method subsequent to FIG. **40**A.

FIG. **41** is a diagram illustrating a step of attaching a ferrule to a tip of an optical fiber extending from the terminal of an optical fiber cord in the optical fiber connector assembling method according to the fourth embodiment.

FIG. **42**A is a sectional view illustrating an optical fiber connector and a cap-attached optical fiber connector according to a fifth embodiment of the invention and is a sectional view taken along a plane in which a multi-core optical fiber is arranged.

FIG. **42**B is a sectional view illustrating the optical fiber connector and the cap-attached optical fiber connector shown in FIG. **42**A and is a sectional view taken along a plane perpendicular to the plane shown in FIG. **23**A and parallel to the length direction of the optical fiber.

FIG. **43**A is a sectional view illustrating a part (a splice reinforcing portion and the vicinity thereof) of the optical fiber connector shown in FIGS. **42**A and **42**B and is a sectional view taken along the plane in which the multi-core optical fiber is arranged.

FIG. **43**B is a sectional view illustrating the part (the splice reinforcing portion and the vicinity thereof) of the optical fiber connector shown in FIGS. **42**A and **42**B and is a sectional view taken along a plane perpendicular to the plane shown in FIG. **43**A and parallel to the length direction of the optical fiber.

FIG. **44** is a diagram illustrating the relationship between the other end portion of the inserted optical fiber and the front end portion of the external optical fiber in the splice reinforcing portion shown in FIGS. **43**A and **43**B.

FIG. **45**A is a perspective view illustrating the structure of a reinforcing member (a pinch member) (a first reinforcing member) used to assemble the splice reinforcing portion shown in FIGS. **43**A and **43**B.

FIG. **45**B is a perspective view illustrating a second reinforcing member of the splice reinforcing portion shown in FIGS. **43**A and **43**B.

FIG. **46** is a diagram illustrating a method of incorporating the pair of reinforcing members shown in FIGS. **45**A and **45**B.

FIG. **47** is a diagram illustrating a method of incorporating the pair of reinforcing members shown in FIGS. **45**A and **45**B.

FIG. **48** is a sectional view illustrating the relationship between adhesion layers of the reinforcing members when the pair of reinforcing members shown in FIGS. **45**A and **45**B is integrated.

FIG. **49** is a sectional view illustrating a state where the pair of reinforcing members shown in FIGS. **45**A and **45**B is integrated and a fusion-spliced portion in which optical fibers are fusion-spliced is pinched therebetween.

FIG. **50** is a sectional view illustrating the work of incorporating a pair of reinforcing members and pinching a fusion-spliced portion in which optical fibers are fusion-spliced therebetween in a step of assembling the optical fiber connector shown in FIGS. **42**A and **42**B.

FIG. **51**A is a perspective view illustrating the structure of an optical fiber connector cap which can be attached to the front end portion of the optical fiber connector shown in FIGS. **42**A and **42**B.

FIG. **51**B is a perspective view illustrating the structure of the optical fiber connector cap which can be attached to the front end portion of the optical fiber connector shown in FIGS. **42**A and **42**B.

FIG. **51**C is a perspective view illustrating the structure of the optical fiber connector cap which can be attached to the front end portion of the optical fiber connector shown in FIGS. **42**A and **42**B.

FIG. **52** is a perspective view illustrating a tensile member fixing step in the method of assembling the optical fiber connector shown in FIGS. **42**A and **42**B.

FIG. **53**A is a diagram illustrating another example of the tensile member fixing step in the optical fiber connector assembling method according to the invention and is a diagram illustrating a constitution fixing a tensile fiber to a swage ring attachment portion of the housing of the optical fiber connector using a swage ring.

FIG. **53**B is a diagram illustrating another example of the tensile member fixing step subsequent to FIG. **53**A.

FIG. **54** is a diagram illustrating another example of the optical fiber connector cap according to the invention.

FIG. **55** is a perspective view illustrating an example of an assembling tool.

FIG. **56** is a plan view of the assembling tool shown in FIG. **55**.

FIG. **57** is a side view of the assembling tool shown in FIG. **55**.

FIG. **58** is a longitudinal sectional view of the assembling tool shown in FIG. **55**.

FIG. **59** is a partially-enlarged plan view of the assembling tool shown in FIG. **55**.

FIG. **60** is a cross-sectional view of the assembling tool shown in FIG. **55**.

FIG. **61** is a diagram illustrating the flow of a method of assembling a splice reinforcing portion using the assembling tool shown in FIG. **55**.

FIG. **62** is a diagram illustrating the flow subsequent to FIG. **61**.

FIG. **63** is a diagram illustrating the flow subsequent to FIG. **62**.

FIG. **64** is a diagram illustrating the flow subsequent to FIG. **63**.

FIG. **65** is a diagram illustrating the flow of the method of assembling a splice reinforcing portion using the assembling tool shown in FIG. **55**.

FIG. **66** is a diagram illustrating the flow subsequent to FIG. **65**.

FIG. **67** is a diagram illustrating the flow subsequent to FIG. **66**.

FIG. **68** is a diagram illustrating the flow subsequent to FIG. **67**.

FIG. **69** is a perspective view illustrating a pressing jig pressing the first reinforcing member toward the second reinforcing member on the assembling tool shown in FIG. **55**.

FIG. **70** is a perspective view illustrating the pressing jig shown in FIG. **69** as viewed from another direction.

FIG. **71** is a diagram illustrating a usage of the pressing jig shown in FIG. **69**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

Hereinafter, the invention will be described on the basis of an exemplary embodiment with reference to the accompanying drawings.

FIGS. **1**A and **1**B show an optical fiber connector **10** according to a first embodiment of the invention and FIGS. **2**A and **2**B show an important part of the optical fiber connector **10**. The optical fiber connector **10** receives a splice reinforcing portion **50**, in which the other end portion **43** of an inserted optical fiber **40** of which one end portion **42** is fixed to a ferrule **12** is fusion-spliced to a front end portion **46** of an external optical fiber **45** and the fusion-spliced portion **44** is pinched between a pair of reinforcing members **51** and **54** to reinforce the fusion-spliced portion, in a housing or the like. FIGS. **1**A and **1**B may be comprehensively referred to as "FIG. **1**".

In the following description, in order to distinguish both sides in the length direction (the lateral direction in FIG. **1**) of an optical fiber, the side which a joint end face **14** of the ferrule **12** faces (the left side in FIG. **1**) may be referred to as "front" and the opposite side (the right side in FIG. **1**) may be referred to as "rear". FIGS. **2**A and **2**B may be comprehensively referred to as "FIG. **2**" and FIGS. **4**A and **4**B may be comprehensively referred to as "FIG. **4**".

An external optical fiber **45** is formed of an optical transmission medium such as an optical fiber cord or an optical fiber cable having an optical fiber. In this embodiment, the external optical fiber **45** is an optical fiber cord including a multi-core optical fiber core **47** including an optical fiber tape core in which a plurality optical fibers (optical fiber wires, which are not shown) are arranged in parallel in the lateral direction perpendicular to the length direction thereof, a tubular sheath **48** surrounding the multi-core optical fiber core **47**, and a tensile fiber **49** received between the optical fiber core **47** and the sheath **48**. In the front end portion **46** of the external optical fiber **45**, the resin coating of the optical fiber core **47** and the resin coating of the optical fiber wires are removed and each of a plurality of bare optical fibers (parts of core and clad) are separated.

Examples of the number of bare optical fibers **46** (the number of cores) included in the optical fiber core **47** include 2, 4, 8, and 12. In FIG. **1**A, the 12-core constitution is simplified and only 6 cores are shown. The optical fiber cord in this embodiment has a constitution in which a single optical fiber tape core is received in a sheath, but is not particularly to this constitution. For example, a constitution in which a plurality of single-core optical fiber cores are received in a single sheath, a constitution in which a plurality of optical fiber tape cores are received in a single sheath, and a constitution in which one or more optical fiber tape cores and signal-core optical fiber cores are received in a single sheath can be employed as the constitution of the external optical fiber.

Since an alignment mechanism such as a V groove is not necessary for a pair of reinforcing members **51** and **54** to be described later, the number of cores of the optical fiber which are held between a pair of reinforcing members **51** and **54** is not specified depending on the structure of a pair of reinforcing members **51** and **54**, as long as it can be received within the width range of adhesion layers **53** and **56**. The specification of a pair of reinforcing members **51** and **54** applied to optical fiber connectors with different numbers of cores such as 2 cores, 4 cores, 8 cores, and 12 cores can be used in common. That is, by changing only the ferrule to a ferrule having a suitable number of cores, an optical fiber connector having a different number of cores can be constructed, thereby contributing to a decrease in cost.

The sheath **48** is formed of a resin such as polyethylene and preferably has flexibility. A plurality of tensile fibers **49** extend along the length direction of the optical fiber and functions as a tensile member accepting a tensile force (tension) to the optical transmission medium. The fiber material used for the tensile fiber **49** is not particularly limited as long as it can provide a necessary tensile strength, and examples thereof include aramid fiber, glass fiber, and carbon fiber.

The tensile member or the sheath is not essential to the invention. For example, an optical fiber core or an optical fiber tape core not having a sheath may be used as the external optical fiber. In some structures of an optical fiber cable or the like, metal wires such as steel wires or various wires such as fiber-reinforced plastic (FRP) may be used as the tensile member. Examples of the optical fiber cable include an optical drop cable and an optical indoor cable.

The inserted optical fiber **40** is an optical fiber of which one end portion **42** is fixed to the ferrule **12** and of which the other end portion **43** protrudes (extends) backward from the ferrule **12**. In this embodiment, the inserted optical fiber **40** includes a multi-core optical fiber core **41** which is an optical fiber tape core, and the resin coating of the optical fiber core **41** and the resin coating of the optical fiber wires are removed in one end portion **42** and the other end portion **43** of the optical fiber core **41** so as to separate into a plurality of bare optical fibers (parts of core and clad).

The optical fiber used as the inserted optical fiber **40** is not limited to the multi-core optical fiber, but a structure in which one or more short single-core optical fibers are inserted into a single ferrule, a structure in which one or more optical fiber tape cores and single-core optical fiber cores are received in a single ferrule, or the like may be employed.

As shown in FIG. **3**, the other end portion **43** of the inserted optical fiber **40** and the front end portion **46** of the external optical fiber **45** correspond to each other in a one-to-one manner and are fusion-spliced to each other. As shown in FIG. **2**, the fusion-spliced portion **44** of the other end portion **43** of the inserted optical fiber **40** and the front end portion **46** of the external optical fiber **45** is pinched between a pair of reinforcing members **51** and **54** to reinforce the fusion-spliced portion. The ferrule **12** around the inserted optical fiber **40** is not shown in FIG. **3**, but one end portion **42** of the inserted optical fiber **40** is preferably fixed into an optical fiber insertion hole **13** of the ferrule **12** before the fusion-splice to the external optical fiber **45**.

As shown in FIG. **2**, the ferrule **12** includes a front end face (joint end face) **14** butt-jointed to a ferrule (not shown) of another optical fiber connector, a rear end face **16** which is the opposite end face of the joint end face **14**, optical fiber insertion holes (micro holes) **13** opened in the joint end face **14**, and a boot-receiving hole **17** opened in the rear end face **16**. The ferrule **12** can be formed, for example, as an integrated molded product formed of plastic. The joint end face **14** of the ferrule **12** may be a vertical face perpendicular to the central axis (substantially matched with the optical axis of the optical fiber **42**) of the optical fiber insertion holes **13**, or may be an inclined face inclined in a predetermined direction corresponding to a ferrule of another optical fiber connector.

The optical fiber insertion holes **13** are formed in the same number as the number of optical fibers in one end portion **42** of the inserted optical fiber **40**. For example, a method of injecting an adhesive into the optical fiber insertion holes **13** to adhere to the bare optical fibers can be simply used as the method of fixing the bare optical fibers which are one end portion **42** of the inserted optical fiber **40** to the ferrule **12**. The optical fiber insertion holes **13** are connected to the boot-receiving hole **17**. A ferrule boot **18** is attached around the optical fiber core **41** and is received in the boot-receiving hole **17**. The ferrule boot **18** is preferably formed of a flexible material such as rubber or elastomer, but the ferrule boot **18** may be formed of a material such as a resin or a metal having low flexibility.

Examples of the number of optical fiber insertion holes **13** (the number of cores) formed in the ferrule **12** include 2, 4, 8, and 12. In FIG. **1**A, the structure of 12 cores is simplified and only 6 cores are shown. In the optical fiber connector **10** according to this embodiment, a single-core ferrule may be used as the ferrule **12**.

The optical fiber insertion holes **13** on the joint end face **14** of the multi-core ferrule **12** are arranged in a line to match with the arrangement of optical fibers pinched between the reinforcing members **51** and **54** to be described later. The invention is not limited to the constitution in which the arrangement of optical fibers in the ferrule **12** are set to be the same as the arrangement of optical fibers in the splice reinforcing portion **50**, but the arrangement of optical fibers separated for each core between the ferrule **12** and the splice reinforcing portion **50** may be changed.

For the purpose of alignment when coupling the ferrule **12** to another ferrule of another optical fiber connector, a guide pin **15** passing through the joint end face **14** and the rear end face **16** may be provided. The tip of the guide pin **15** protrudes from the joint end face **14** and the guide pin is inserted into a guide pin insertion hole (not shown) formed in the ferrule of another optical fiber connector to suppress the shaking in the direction along the joint end face **14** (such as the vertical direction in FIG. **2**A, the vertical direction in FIG. **2**B, or an inclined direction obtained by combining the directions). When a guide pin is provided to a ferrule of another optical fiber connector, a guide pine insertion hole is provided to the ferrule **12**. A hole **15***a* formed as a trace of pulling out the guide pin **15** from the ferrule **12** may be used as the guide pin insertion hole **15***a*. Alternatively, the ferrule **12** having a guide pin insertion hole formed thereon instead of the guide pin **15** may be used at the first time.

Preferably, the guide pin **15** can be attached and detached by the insertion and the pulling-out into and from the guide pin insertion hole **15***a*, since it can be easily determined on the splicing site with which of the optical fiber connector **10** and another optical fiber connector to provide the guide pin. For example, when the jointed state of the optical fiber connector **10** and another optical fiber connector is released, a pin clamp **19** is disposed on the rear end face **16** of the ferrule **12** so as to prevent the guide pin **15** from being unintentionally pulled out. In this embodiment shown in FIG. **1**, the pin clamp **19** fills a gap between the ferrule **12** and the splice reinforcing portion **50** and includes a spring seat **20** for accepting an impelling force (pressing force based on elasticity) from a ferrule spring **24**. Accordingly, even when the guide pin **15** is not installed in the ferrule **12**, the pin clamp **19** is attached to the ferrule **12**. The pin clamp **19** can be inserted into and fixed to the ferrule **12** by, for example, irregularity or the like (not shown).

The guide pin **15** may be fixed to the guide pin insertion hole **15***a* (for example, by adhesion or embedment through insert molding) for use.

An example of the reinforcing members **51** and **54** used in this embodiment is shown in FIGS. **4** to **7**. The first reinforcing member **51** used in the upper side of FIG. **2**B is shown in FIG. **4**A and the second reinforcing member **54** used in the lower side of FIG. **2**B is shown in FIG. **4**B. In this embodiment, the reinforcing members **51** and **54** includes reinforcing member bodies **52** and **55** formed of a hard material such as a resin or a metal and adhesion layers **53** and **56** disposed on the inner surfaces coming in contact with the other end portion **43** of the inserted optical fiber **40** and the front end portion **46** of the external optical fiber **45**, respectively.

As shown in FIG. **16**, the adhesion layers **53** and **56** are depressed at the position where the inserted optical fiber and the external optical fiber (which are comprehensively represented by the optical fibers F in FIG. **16**) come in contact with each other to closely adhere to the outer circumferential surfaces of the optical fibers F in the vicinity of the fusion-spliced portion **44**. Accordingly, a mechanism such as a V groove or a U groove used to align the optical fibers is not necessary to form in the inner surfaces of the reinforcing members. In this embodiment, since the other end portion **43** of the inserted optical fiber **40** and the front end portion **46** of the external optical fiber **45** are fusion-spliced in advance, the splice loss is small and the loss is not increased due to the axial misalignment (misalignment of the optical axes) of both optical fibers or the separation of the end faces.

In the case of the groove-like mechanism such as a V groove or a U groove, when the outer diameter in the vicinity of the fusion-spliced portion **44** is greater than the original outer diameter of the optical fibers (before the fusion splice), an excessive pressing force acts on the fusion-spliced portion **44**, thereby shortening the lifetime. On the other hand, when the outer diameter in the vicinity of the fusion-spliced portion **44** is smaller, the positioning of the optical fibers is not stabilized and the positions of the optical fibers may be misaligned in the lateral direction in the grooved mechanism. On the contrary, when the adhesion layers **53** and **56** have deformability following the outer circumferential surface of the optical fibers F, the positioning of the optical fibers F is stabilized, thereby suppressing the warp of the optical fibers F with the lapse of time or the increase in loss.

In this embodiment, as shown in FIG. **16**, at the position where the optical fibers F in the fusion-spliced portion **44** are pinched between a pair of reinforcing members **51** and **54**, the adhesion layers **53** and **56** of the pair of reinforcing members **51** and **54** closely adhere to each other on both sides (on both sides in the width direction perpendicular to the length direction) of the optical fibers F. Accordingly, it is possible to suppress the warp of the optical fibers F with the lapse of time or the increase in loss. Since there is no gap between the opposed adhesion layers **53** and **56**, it is possible to prevent the permeation of moisture or the like which may adversely influence the lifetime of bare optical fibers (particularly, in the case of quartz optical fibers). When an opaque material is used for the adhesion layers **53** and **56**, it is possible to prevent the leakage of light (leaking light) from the gap between the adhesion layers **53** and **56**.

The adhesion layers **53** and **56** are preferably formed of a flexible elastic material such as rubber or elastomer. Accordingly, when the optical fibers F are pinched between the adhesion layers **53** and **56** with a pressing force, the adhesion layers are depressed at the position where they come in contact with the optical fibers F and thus more closely adhere to the outer circumferential surfaces of the optical fibers F with the elastic force of the adhesion layers **53** and **56**. The elastic force of the adhesion layers **53** and **56** has such a magnitude that the original flat surface is restored, when the pressing force is released after the depression.

When a foamed material is used for the adhesion layers **53** and **56**, it is preferable that bubbles be small and the bubbles be independent of each other (the bubbles be not connected). An adhesive (pressure-sensitive adhesive) may be used as the adhesion layers **53** and **56**, but it is preferable that the adhesion layers **53** and **56** be non-adhesive (the adhesive force is small or zero to such an extent that the bare optical fibers **43** and **46** can be easily detached after the temporary disposing) so as to dispose the bare optical fibers **43** and **46** again after temporarily disposing them. When the adhesive force of the surfaces of the adhesion layers **53** and **56** is weak, it is difficult to cause the adhesion layers **53** and **56** to closely adhere to the bare optical fibers **43** and **46**. Accordingly, it is preferable that the positional relationship between the first reinforcing member **51** and the second reinforcing member **54** be fixed to maintain appropriate pressing forces from both sides.

As shown in FIGS. **4** to **6**, a pair of reinforcing members **51** and **54** includes protuberance portions **61** and recessed portions **62**, respectively, engaging with each other on both sides in the width direction (the direction perpendicular to the paper surface of FIGS. **5** and **6**) which is the direction perpendicular to the length direction of the inserted optical fiber **40** and the external optical fiber **45**. By causing the protuberance portions (engaging protuberance portions) **61** and the recessed portions (engaging recessed portions) **62** to engage with each other, the state where the adhesion layers **53** and **56** of the pair of reinforcing members **51** and **54** closely adhere to each other is maintained. Accordingly, even when the adhesion therebetween is not maintained with only the adhesive force between the adhesion layers **53** and **56**, it is possible to cause the adhesion layers **53** and **56** to satisfactorily closely adhere to each other and thus to prevent the first reinforcing member **51** and the second reinforcing member **54** from being separated from each other.

In this embodiment, as shown in FIG. **4**B, the body **55** of the second reinforcing member **54** includes a bottom portion **57** and side wall portions **58** and **58** formed on both sides in the width direction thereof and the engaging recessed portion **62** is a through-hole formed in the side wall portions **58**. Accordingly, it is possible to easily confirm the engagement state of the engaging recessed portions **61** from the outside with the naked eye or a magnifier. From the viewpoint of the incorporation of the reinforcing members **51** and **54**, only the inner surfaces of the side wall portions **58** to form holes (blind holes) not penetrating the outer surface as the engaging recessed portions. Instead of forming the engaging protuberance portions in the first reinforcing member and forming the engaging recessed portions in the second reinforcing member **54**, the engaging protuberance portions may be formed in the second reinforcing member and the engaging recessed portions may be formed in the first reinforcing member **54**. Various combinations such as a combination of alternately forming the engaging protuberance portion and the engaging recessed portion in the first reinforcing member and alternately forming the engaging recessed portion and the engaging protuberance portion in the second reinforcing member so as to be complementary thereto may be employed.

The side wall portion **58** of the second reinforcing member **54** is divided into a plurality of parts (tongue-shaped parts) by cutouts **59** and one or more engaging recessed portions **62** are disposed on one side. Accordingly, as shown in FIG. **7**, when the first reinforcing member **51** is interposed between the pair of side wall portions **58** opposed to each other in the width direction, the side wall portions **58** having the engaging recessed portions **62** can be independently opened and closed. Even when a set of engaging portions is loosened, the other engaging portions are not loosened therewith. In the front end portions (the upside in FIG. **7**) of the side wall portions **58** protruding from the bottom wall portion **57**, an inclined surface **58***a* is formed on the inner surface side of the side wall portions **58**. Accordingly, it is possible to easily interpose the first reinforcing member **51** between the pair of side walls **58** opposed to each other in the width direction. When the engaging protuberance portions **61** and the engaging recessed portions **62** are disengaged from each other after the pair of reinforcing members **51** and **54** are combined, a tool may be inserted into the clearance between the inclined surface **58***a* of the side wall portion **58** and the first reinforcing member body **52** to easily push and open the side wall portion **58** to the outside in the width direction.

The adhesion layers **53** and **56** in this embodiment include swelled portions **53***a* and **56***a* of which the surface is raised higher in the vicinity of the fusion-spliced portion **44** and thus the pressing force can be kept higher between the swelled portions **53***a* and **56***a*. Alleviated portions **53***b* and **56***b* which are lower in height than the swelled portions **53***a* and **56***a* and which are alleviated in pressing force are disposed on both sides of the swelled portions **53***a* and **56***a* (on both sides in the length direction of the bare optical fibers **43** and **46**). Examples of a method of forming the swelled portions **53***a* and **56***a* include a method of forming protrusions in the reinforcing member bodies **52** and **55** in the back of the adhesion layers **53** and **56** and a method of partially increasing the thicknesses of the adhesion layers **53** and **56**.

The sets of engaging portions including the sets of the engaging protuberance portions **61** and the engaging recessed portions **62** are disposed in the length direction of the optical fibers. Specifically, one set (or two or more sets) is disposed at the position of the swelled portions **53***a* and **56***a*, one set (or two or more sets) is disposed at the position of the alleviated portions **53***b* and **56***b* on the side of the inserted optical fiber **40**, and one set (or two or more sets) is disposed at the position of the alleviated portions **53***b* and **56***b* on the side of the external optical fiber **45**. Accordingly, the pressing force applied to the fusion-spliced portion **44** from the swelled portions **53***a* and **56***a* can be adjusted by adjusting the positional relationship of the engaging portions in the swelled portions **53***a* and **56***a*. Even when the pressing force of the swelled portions **53***a* and **56***a* is excessively strong and the engaging portions are loosened due to the repulsive force between the swelled portions **53***a* and **56***a*, the engaging portions in the alleviated portions **53***b* and **56***b* are not loosened well, thereby preventing the first reinforcing member **51** and the second reinforcing member **54** from being separated from each other.

As shown in FIG. **2**B, a ferrule boot **18** covering the part of the inserted optical fiber **40** extending from the ferrule **12** is attached to the ferrule **12**. The pair of reinforcing members **51** and **54** (specifically, the bodies **52** and **55** thereof) include protrusions serving as boot clamping portions **52***a* and **55***a* at ends close to the ferrule **12** and the ferrule boot **18** is clamped between the boot clamping portions **52***a* and **55***a*. Accordingly, both ends of the ferrule boot **18** is tightly held between the ferrule **12** and the pair of reinforcing members **51** and **54**, thereby satisfactorily preventing the warp or damage of the inserted optical fiber **40**.

The method of assembling the optical fiber connector **10** according to this embodiment includes a step of fusion-splicing the other end portion **43** of the inserted optical fiber **40**, of which one end portion **42** is fixed to the ferrule **12** and of which the other end portion **43** protrudes from the ferrule **12**, to the front end portion **46** of the external optical fiber **45** and then pinching the fusion-spliced portion **44** between the pair of reinforcing members **51** and **54** to integrate them into a body. Accordingly, the adhesion layers **53** and **56** disposed on the inner surfaces of the reinforcing members **51** and **54** can be caused to closely adhere to the outer circumferential surfaces of the bare optical fibers **43** and **46** in the fusion-spliced portion **44**.

The reinforcing members **51** and **54** in this embodiment include a first reinforcing member **51** having a shaft portion **60** at an end opposite to the ferrule **12** and a second reinforcing member **54** opposed to the first reinforcing member **51**. A suitable assembling method in this case will be described below with reference to FIGS. **8** to **13**. In FIGS. **12** and **13**, the bare optical fibers **43** and **46** are shown to be visible so as to easily see the positions of the bare optical fibers **43** and **46** between the adhesion layers **53** and **56**. However, it is preferable that the bare optical fibers **43** and **46** be sealed between the adhesion layers **53** and **56** after closing the reinforcing members **51** and **54**, as shown in FIG. **16**.

First, as shown on the upper side of FIG. **8**, a structure in which the other end portion **43** of the inserted optical fiber **40** protruding from the ferrule **12** is fusion-spliced to the front end portion **46** of the external optical fiber **45** is prepared. In this embodiment, a ferrule to which the guide pin **15**, the ferrule boot **18**, the pin clamp **19**, and the internal optical fiber **40** are attached in advance is used as the ferrule **12** and the other end portion **43** of the inserted optical fiber **40** has only to be fusion spliced to the front end portion **46** of the external optical fiber **45** on the splicing site. When the pin clamp **19** can be attached and detached after assembling the splice reinforcing portion **50**, the steps shown in FIGS. **8** to **13** may be performed in a state where the guide pin **15** or the pin clamp **19** is detached from the ferrule **12**.

As shown on the lower side of FIG. **8**, the second reinforcing member **54** is held on the assembling tool **70**. The assembling tool **70** includes a reinforcing member holding portion **71** holding the second reinforcing member **54** at a predetermined position, a core holding portion **72** holding a part of the optical fiber core **47** of the external optical fiber **45**, an arm portion **73** (see FIG. **10**) having a bearing portion **74** rotatably holding the shaft portion **60** of the first reinforcing member **51**, and a pressing cover **75** (see FIG. **11**) pressing the part of the optical fiber core **47** of the external optical fiber **45** against the core holding portion **72**.

The reinforcing member holding portion **71** preferably has a grooved structure to holding the second reinforcing member **54** from both sides in the width direction (the lateral direction in FIG. **7**) of the bottom wall portion **57** so as for the second reinforcing member **54** not to move in the width direction. In this embodiment, the side wall portions **58** protrude upward from the bottom wall portion **57**. Accordingly, when the first reinforcing member **51** is pushed between both side wall portions **58**, both side wall portions **58** may be opened until the protuberance portions **61** of the first reinforcing member **51** reach the engaging recessed portions **62** from the upside.

As shown in FIG. **9**, the fusion-spliced portion **44** of the bare optical fibers **43** and **46** is placed on the second reinforcing member **54**. The adhesion layer **56** formed on the inner surface of the second reinforcing member **54** faces the upside and the fusion-spliced portion **44** is placed on the swelled portion **56***a* of the adhesion layer **56**. Since the bare optical fibers **43** and **46** are thin (generally in the diameter range of about 60 to about 150 μm, for example, 125 μm more or less) and is not desirable to directly touch with a hand, it is preferable that a holder not shown be provided under the ferrule **12** and a thick part of the holder and the external optical fiber **45** be picked up for work.

As shown in FIG. **10**, the shaft portion **60** of the first reinforcing member **51** is held in the bearing portion **74**.

At this time, the adhesion layer **53** formed on the inner surface of the first reinforcing member **51** is disposed to face the second reinforcing member **54**.

As shown in FIG. **11**, the pressing cover **75** is closed from the upside of the optical fiber core **47** of the external optical fiber **45** to pinch the optical fiber core **47** between the core holding portion **72** and the pressing cover **75**. Before closing the pressing cover **75**, the external optical fiber **45** is preferably attracted in the direction (to the right side in FIG. **11**) in which it goes apart from the ferrule **12** with a hand to remove the loosening of the bare optical fibers **43** and **46** or the optical fiber cores **41** and **47** before and after. When attracting the external optical fiber **45**, the end portion (specifically, the boot clamping portion **55***a*) of the second reinforcing member **54** on the side of the ferrule **12** comes in contact with the rear end of the ferrule **12** (specifically, the pin clamp **19**) and the movement to the side of the inserted optical fiber **40** is stopped, whereby it is not necessary to particularly press the ferrule **12** with a hand or the like.

In the above-mentioned steps, the time of performing the step of holding the shaft portion **60** of the first reinforcing member **51** in the bearing portion **74** is not particularly limited as long as it is before the fusion-spliced portion **44** is pinched between the pair of reinforcing members **51** and **54**. For example, the step may be performed after the pressing cover **75** is closed. By providing the pressing cover **75**, the state where tension is applied to the optical fiber **45** can be maintained without pressing the optical fiber, thereby improving the workability. Examples of the method of opening and closing the pressing cover **75** include methods using a magnet, a screw, a spring, or the like in addition to a method using a latch having an engaging claw or protrusion.

In this embodiment, the optical fiber core **47** is pinched between the core holding portion **72** and the pressing cover **75**, but a part of the optical fiber cord or the optical fiber cable may be pinched therebetween.

As shown in FIG. **12**, the first reinforcing member **51** is rotationally moved to the second reinforcing member **54** about the shaft portion **60** in the bearing portion **74** to pinch the fusion-spliced portion **44** between the pair of reinforcing members **51** and **54**. Accordingly, the splice reinforcing portion **50** can be assembled to the rear side of the ferrule **12** and the bare optical fibers **43** and **46** are sealed between the adhesion layers **53** and **56**.

When pinching the fusion-spliced portion **44** between the pair of reinforcing members **51** and **54**, the engaging protuberance portions **61** are made to engage with the engaging recessed portions **62**, as shown in FIG. **16**. The ferrule boot **18** is clamped between t boot clamping portions **52***a* and **55***a* formed at the ends of the pair of reinforcing members **51** and **54** on the side of the ferrule **12**.

Then, as shown in FIG. **13**, the structure (see FIG. **2** for the sectional structure) in which the splice reinforcing portion **50** is assembled to the rear side of the ferrule **12** is detached from the assembling tool **70**. Since the bearing portion **74** has a U shape in which the bottom is a semicircular shape and the top is horizontally opened, the shaft portion **60** can be easily detached from the bearing portion **74** by raising the splice reinforcing portion **50** with a hand or the like.

In this way, by using the first reinforcing member **51** having the shaft portion **60** of which the central axis line is perpendicular to the length direction of the optical fibers and the assembling tool **70** having the bearing portion **74**, the first reinforcing member **51** falls out in the direction parallel to the length direction of the optical fibers with respect to the second reinforcing member **54** and it is thus possible to suppress a rotational (twisting) force about the axis of the optical fibers when the first reinforcing member **51** comes in contact with the optical fibers.

Since the positional relationship between the reinforcing member holding portion **71** and the bearing portion **74** are appropriately determined in advance, the bearing portion **74** supporting the shaft portion **60** can be used as a reference for positioning the first reinforcing member **51** with respect to the second reinforcing member **54**. That is, since the second reinforcing member **54** is not erroneously moved when attaching the shaft portion **60** to the bearing portion **74**, the work is facilitated even with the small size of the reinforcing members **51** and **54**.

By assembling the housing receiving the ferrule **12** and the splice reinforcing portion **50** after assembling the splice reinforcing portion **50** to the rear side of the ferrule **12**, the optical fiber connector **10** shown in FIG. **1** can be completed.

The optical fiber connector **10** described in this embodiment is a multi-core optical fiber connector and the example shown in the drawings is an MPO type optical fiber connector (F13 type multi-core optical fiber connector defined in the JIS C5982, MPO: Multi-fiber Push On). The optical fiber connector applicable to the invention is not limited to the single-core type or the multi-core type.

The housing of the optical fiber connector **10** includes a sleeve-like (tubular) plug frame **21** and a sleeve-like (tubular) stop ring **30** attached to the rear end of the plug frame **21**. The side surface of the ferrule **12** is held from the surrounding by the front opening **22** of the plug frame **21**. An engaging claw **33** which can engage with an engaging window **27** formed in the side wall portion of the plug frame **21** is formed in the outer surface of the stop ring **30** so as to integrate the plug frame **21** and the stop ring **30** into a body. The ferrule spring **24** is disposed around the splice reinforcing portion **50**, the front end of the spring **24** is brought into contact with the spring seat **20** at the rear end of the pin clamp **19**, and the rear end of the spring **24** is brought into contact with the spring seat **31** at the front end of the stop ring **30**.

When the joint end face **14** of the ferrule **12** is jointed to a ferrule of another optical fiber connector, the ferrule **12** is guided in the opening **22** and pushed backward to contract the ferrule spring **24**, an appropriate force acts between the joint end face **14** of the ferrule **12** and a joint end face of a ferrule of another optical fiber connector, thereby bringing the joint end faces into close contact with each other. When the joint between the ferrule **12** and the ferrule of another optical fiber connector is released, the ferrule spring **24** is stretched and the ferrule **12** moves in the opening **22** and is restored to the original position.

An engaging portion **23** used for the MPO type connector plug to engage with an engaging claw (not shown) of an MPO type connector adaptor or a receptacle is disposed on both sides (both side in the vertical direction in FIG. **1**A) in the width direction of the plug frame **21**. A coupling **25** is disposed on the outer circumference of the plug frame **21**, and a pair of coupling springs **26** and **26** is received between the outer circumferential surface of the plug frame **21** and the inner circumferential surface of the coupling **25**. Accordingly, the coupling **25** can move forward and backward relative to the plug frame **21** with the stretching and contracting of the coupling springs **26** and **26**. The engaging portion **23** or the coupling **25** has the same constitution as defined in the JIS or the like as the MPO type connector plug.

When the invention is applied to different types of optical fiber connectors, the constituents required for the joint (connector joint) of the optical fiber connectors are installed in the ferrule or the housing.

In the optical fiber connector **10** shown in FIG. **1**, a cap **11** is provided to protect the front end portion of the ferrule **12** of the optical fiber connector plug or the like. The cap **11** is detached in use (at the time of jointing to another optical fiber connector). A key groove **11***a* locked to a key **21***a* formed on one of the side surfaces of the plug frame **21** is formed in the inner surface of the cap **11**. The key **21***a* of the plug frame **21** is conventionally installed to prevent the vertically-reverse use (of the top and bottom in FIG. **1**B) of an optical fiber connector plug, and the key groove **11***a* of the cap **11** is installed on both sides in the vertical direction. Accordingly, it is possible to attach the cap **11** to the optical fiber connector **10** without distinguishing the upside and downside of the cap **11**.

A through-hole **32** passing in the front-rear direction (the lateral direction in FIG. **1**) along the length direction of the optical fiber is formed in the stop ring **30**. The cross-sectional shape (the sectional shape in the plane perpendicular to the length direction of the optical fiber) of the through-hole **32** has at least a size which can receive the shape of the cross-sectional shape of the splice reinforcing portion **50**. Accordingly, when the stop ring **30** is pushed in toward the plug frame **21** from the rear side of the splice reinforcing portion **50** in a state where the ferrule **12** is inserted into the opening **22** of the plug frame **21**, the stop ring **30** is prevented from interfering with the splice reinforcing portion **50** (hindering the push thereof). When the stop ring **30** is pushed in toward the plug frame **21** from the rear side of the splice reinforcing portion **50**, the engaging claw **33** is drawn into the splice reinforcing portion **50** just before the engaging claw **33** reaches the engaging window **27**. Accordingly, on the back surface side of the engaging claw **33**, a groove **32***a* is formed in the inner surface of the through-hole **32**, thereby avoiding the interference of the splice reinforcing portion **50** with the back surface of the engaging claw **33**.

An external screw **34** is formed on the outer circumferential surface of the rear end portion of the stop ring **30**. An internal screw **36** formed on the inner circumferential surface of the screw ring **35** can be fastened to the external screw **34**. The front end portion of the tensile fiber **49** of the external optical fiber **45** can be pinched and fixed between the external screw **34** and the internal screw **36**. The screw ring **35** includes an opening **37** at the rear end thereof, and a part of the tensile fiber **49** of the external optical fiber **45** and the optical fiber core **47** is inserted into the opening **37**. The cross-sectional shape (the sectional shape in the plane perpendicular to the length direction of the optical fiber) of the opening **37** preferably has a certain opening size so as to avoid the contact of the tensile fiber **49** with the splice reinforcing portion **50**.

A boot **65** for an external optical fiber for protecting the external optical fiber **45** is attached to the outer circumferential surface of the screw ring **35**. The boot **65** is generally formed of a flexible material such as rubber or elastomer. In this embodiment, a protective tube **66** is attached around the sheath **48** of the external optical fiber **45** and an annular locking portion **67** having a large diameter at the front end portion of the tube **66** is inserted into the boot **65**.

The sequence of assembling the housing or the like is not particularly limited, but the following sequence can be employed as an example.

As an advance preparation before the fusion splice, the ferrule spring **24**, the stop ring **30**, the screw ring **35**, the external optical fiber boot **65**, and the protective tube **66** are made to pass around the external optical fiber **45**. These components are preferably arranged on the rear side (the right side in FIG. **1**) so as not to interfere with the fusion splice.

As described above, the bare optical fibers **43** and **46** are fusion-spliced, the splice reinforcing portion **50** is assembled thereto (see FIGS. **8** to **13**), the plug frame **21** is attached thereto from the front side (the left side in FIG. **1**) of the ferrule **12** to dispose the ferrule **12** in the opening **22** of the plug frame **21**, the stop ring **30** is pushed into the plug frame **21** to cause the engaging claw **33** to engage with the engaging window **27**, and the ferrule spring **24** is received along with the ferrule **12** and the splice reinforcing portion **50**. The cap **11** and the coupling **25** may be attached to the plug frame **21** in advance or may be attached thereto after the cap **11** and the coupling **25** are attached to the stop ring **30**.

The front end portion of the tensile fiber **49** is placed on the external screw **34** of the stop ring **30** and the internal screw **36** of the screw ring **35** is fastened to the external screw **34** to fix the front end portion of the tensile fiber **49**. When the front end portion of the tensile fiber **49** extends over the outer circumference of the plug frame **21**, the tensile fiber is cut out if necessary. The boot **65** is attached to the stop ring **30**. The optical fiber connector **10** shown in FIG. **1** can be assembled through this sequence.

When the external optical fiber does not include a tensile fiber, the internal screw **36** of the screw ring **35** is fastened to the external screw **34** of the stop ring **30** to integrate the housing into a body, without pinching the tensile fiber.

(Method of Reinforcing Fusion-spliced Portion of Optical Fiber)

The splice reinforcing portion **50** in this embodiment is not limited to the reinforcement of the fusion-spliced portion **44** in the optical fiber connector, but can be used for a reinforcement method of pinching and reinforcing a fusion-spliced portion **90**, in which end portions **88** and **89** of a first optical fiber **91** and a second optical fiber **92** are fusion-spliced to each other, between a pair of reinforcing members **51** and **54** as shown in FIGS. **14** and **15**.

The assembling tool **80** shown in FIG. **14** includes a reinforcing member holding portion **81** holding the second reinforcing member **54** at a predetermined position, a first core holding portion **82** holding a part of the optical fiber core of the first optical fiber **91**, an arm portion **83** having a bearing portion **84** rotatably holding the shaft portion **60** of the first reinforcing member **51**, a first pressing cover **85** pressing the part of the optical fiber core of the first optical fiber **91** against the first core holding portion **82** from upside of the first core holding portion **82**, a second core holding portion **86** holding a part of the optical fiber core of the second optical fiber **92**, and a second pressing cover **87** pressing the part of the optical fiber core of the second optical fiber **92** against the second core holding portion **86** from upside of the second core holding portion **86**.

A pair of reinforcing members **51** and **54** include adhesion layers **53** and **56** which can be depressed at the position where the first optical fiber **91** and the second optical fiber **92** come in contact with each other on the inner surface which comes in contact with the ends portions **88** and **89** of the first optical fiber **91** and the second optical fiber **92**, as shown in FIGS. **4** to **7**. The first reinforcing member **51** includes a shaft portion **60** at one end in the length direction (in the lateral direction in FIG. **14**) of the first optical fiber **91** and the second optical fiber **92**.

The sequence of assembling the splice reinforcing portion **50** by pinching the fusion-spliced portion **90** between the pair of reinforcing members **51** and **54** is the same as the sequence shown in FIGS. **8** to **12**. The result is shown in FIG. **14**. The state where the assembled splice reinforcing portion **50** is detached from the assembling tool **80** is shown in FIG. **15**.

In this embodiment, the optical fiber cores **91** and **92** are pinched between the core holding portions **82** and **86** and the pressing covers **85** and **87**, but a part of an optical fiber cord or an optical fiber cable may be pinched therebetween.

In this way, by using the first reinforcing member **51** having the shaft portion **60** of which the central axis line is perpendicular to the length direction of the optical fibers **91** and **92** and the assembling tool **80** having the bearing portion **84**, the first reinforcing member **51** falls out in the direction parallel to the length direction of the optical fibers **91** and **92** with respect to the second reinforcing member **54** and it is thus possible to suppress a rotational (twisting) force about the axis of the optical fibers when the first reinforcing member **51** comes in contact with the end portions **88** and **89** of the optical fibers **91** and **92**.

Since the positional relationship between the reinforcing member holding portion **81** and the bearing portion **84** are appropriately determined in advance, the bearing portion **74** supporting the shaft portion **60** can be used as a reference for positioning the first reinforcing member **51** with respect to the second reinforcing member **54**. That is, since the second reinforcing member **54** is not erroneously moved when attaching the shaft portion **60** to the bearing portion **74**, the work is easily carried out even with the small sizes of the reinforcing members **51** and **54**.

While the invention has been described on the basis of an exemplary embodiment, the invention is not limited to the above-mentioned embodiment, but may be modified in various forms without departing from the concept of the invention.

Modification of Optical Fiber Connector

As described above, the external optical fiber to which the optical fiber connector is applied may not have a tensile fiber. An example of an optical fiber connector **10**A which can be used in this case and which has a more simplified constitution is shown in FIGS. **17**A and **17**B. Hereinafter, FIGS. **17**A and **17**B are comprehensively referred to as "FIG. **17**".

The optical fiber connector **10**A can be a tip of an external optical fiber **45**A not having a tensile fiber. The stop ring **38** includes a first half portion **38***a* inserted into the plug frame **21** and a second half portion **38***b* to which the boot **65** is attached, and an engaging claw **33** which can engage with the engaging window **27** of the plug frame **21** is formed on the outer circumferential surface of the first half portion **38***a* of the stop ring **38**. That is, the stop ring **38** having this constitution has a structure in which the stop ring **30** and the screw ring **35** shown in FIG. **1** are integrated into a body.

The sequence of assembling the housing or the like is not particularly limited, but the following sequence may be employed as an example.

As an advance preparation before the fusion splice, the ferrule spring **24**, the stop ring **38**, the external optical fiber boot **65**, and the protective tube **66** are made to pass around the external optical fiber **45**. These components are preferably arranged on the rear side (the right side in FIG. **17**) so as not to interfere with the fusion splice. The cap **11** and the coupling

25 may be attached to the plug frame **21** in advance or may be attached thereto after the cap **11** and the coupling **25** are attached to the stop ring **38**.

As described above, the bare optical fibers **43** and **46** are fusion-spliced, the splice reinforcing portion **50** is assembled thereto (see FIGS. **8** to **13**), the plug frame **21** is attached thereto from the front side (the left side in FIG. **17**) of the ferrule **12** to dispose the ferrule **12** in the opening **22** of the plug frame **21**, the stop ring **38** is pushed into the plug frame **21** to cause the engaging claw **33** to engage with the engaging window **27**, and the ferrule spring **24** is received along with the ferrule **12** and the splice reinforcing portion **50**. The boot **65** is attached to the second half portion **38***b* of the stop ring **38**. The optical fiber connector **10**A shown in FIG. **17** can be assembled through this sequence.

In this way, in the optical fiber connector **10**A according to this modification, since the external optical fiber **45**A does not include a tensile fiber, the assembling sequence is more simplified than the optical fiber connector **10** shown in FIG. **1**.

Second Embodiment

An optical fiber connector **110** according to a second embodiment of the invention will be described below.

FIGS. **23**A and **23**B show an optical fiber connector **110** according to the second embodiment of the invention and FIGS. **24**A and **24**B show an important part of the optical fiber connector **110**. The optical fiber connector **110** has a constitution in which the other end portion **43** of an inserted optical fiber **40** of which one end portion **42** is fixed to a ferrule **12** (optical fiber connector ferrule) is fusion-spliced to a front end portion **46** of an external optical fiber **45** and a splice reinforcing portion **50** in which the fusion-spliced portion **44** is pinched and reinforced between a pair of reinforcing members **51** and **54** is received in a housing or the like. FIGS. **23**A and **23**B may be comprehensively referred to as “FIG. **23**”. Similarly, FIGS. **24**A and **24**B may be comprehensively referred to as “FIG. **24**”.

In the following description, in order to distinguish both sides in the length direction (the lateral direction in FIG. **23**) of an optical fiber, the side which a joint end face **14** of the ferrule **12** faces (the left side in FIG. **23**) may be referred to as “forward” or “front” and the opposite side (the right side in FIG. **23**) may be referred to as “backward”, “rear”, or “toward a base end”. The front-rear direction is the length direction at one end portion **42** of the inserted optical fiber **40** and is also a joint direction when the optical fiber connector **110** is jointed to the opposite optical fiber connector.

An external optical fiber **45** is formed of an optical transmission medium such as an optical fiber cord or an optical fiber cable having an optical fiber. In this embodiment, the external optical fiber **45** is an optical fiber cord including a multi-core optical fiber core **47** including an optical fiber tape core in which a plurality optical fibers (optical fiber wires, which are not shown) are arranged in parallel in the lateral direction perpendicular to the length direction thereof, a tubular sheath **48** surrounding the multi-core optical fiber core **47**, and a tensile fiber **49** received between the optical fiber core **47** and the sheath **48**. In the front end portion **46** of the external optical fiber **45**, the resin coating of the optical fiber core **47** and the resin coating of the optical fiber wires are removed and each of a plurality of bare optical fibers (parts of core and clad) are separated.

Examples of the number of bare optical fibers **46** (the number of cores) included in the optical fiber core **47** include 2, 4, 8, and 12. In FIGS. **23**A, **24**A, and **25**, the 12-core constitution is simplified and only 4 cores are shown. The optical fiber cord in this embodiment has a constitution in which a single optical fiber tape core is received in a sheath, but is not particularly to this constitution. For example, a constitution in which a plurality of single-core optical fiber cores are received in a single sheath, a constitution in which a plurality of optical fiber tape cores are received in a single sheath, and a constitution in which one or more optical fiber tape cores and signal-core optical fiber cores are received in a single sheath can be employed as the constitution of the external optical fiber.

The sheath **48** is formed of a resin such as polyethylene and preferably has flexibility. A plurality of tensile fibers **49** extend along the length direction of the optical fiber and functions as a tensile member accepting a tensile force (tension) to the optical transmission medium. The fiber material used for the tensile fiber **49** is not particularly limited as long as it can provide a necessary tensile strength, and examples thereof include aramid fiber, glass fiber, and carbon fiber.

The tensile member or the sheath is not essential to the invention. For example, an optical fiber core or an optical fiber tape core not having a sheath may be used as the external optical fiber. In some structures of an optical fiber cable or the like, metal wires such as steel wires or various wires such as fiber-reinforced plastics (FRP) may be used as the tensile member. Examples of the optical fiber cable include an optical drop cable and an optical indoor cable.

The inserted optical fiber **40** is an optical fiber of which one end portion **42** is fixed to the ferrule **12** and of which the other end portion **43** protrudes (extends) backward from the ferrule **12**. In this embodiment, the inserted optical fiber **40** includes a multi-core optical fiber core **41** which is an optical fiber tape core, and the resin coating of the optical fiber core **41** and the resin coating of the optical fiber wires are removed in one end portion **42** and the other end portion **43** of the optical fiber core **41** so as to separate into a plurality of bare optical fibers (parts of cores and clad).

The front end of the inserted optical fiber **40** is exposed from the joint end face **14** and is butt-jointed to an optical fiber of the opposite optical fiber connector.

The optical fiber used as the inserted optical fiber **40** is not limited to the multi-core optical fiber, but a structure in which one or more short single-core optical fibers are inserted into a single ferrule, a structure in which one or more optical fiber tape cores and single-core optical fiber cores are received in a single ferrule, or the like may be employed.

As shown in FIG. **25**, the other end portion **43** of the inserted optical fiber **40** and the front end portion **46** of the external optical fiber **45** correspond to each other in a one-to-one manner and are fusion-spliced to each other. As shown in FIG. **24**, the fusion-spliced portion **44** of the other end portion **43** of the inserted optical fiber **40** and the front end portion **46** of the external optical fiber **45** is pinched and reinforced between a pair of reinforcing members **51** and **54** in the splice reinforcing portion **50**.

The reinforcing members **51** and **54** include reinforcing member bodies **52** and **55** formed of a hard material such as resin or metal and adhesion layers **53** and **56** disposed on the inner surfaces which come in contact with the other end portion **43** of the inserted optical fiber **40** and the front end portion **46** of the external optical fiber **45**.

The ferrule **12** around the inserted optical fiber **40** is not shown in FIG. **25**, but one end portion **42** of the inserted optical fiber **40** is preferably fixed into an optical fiber insertion hole **13** of the ferrule **12** before the fusion-splice to the external optical fiber **45**.

As shown in FIGS. **18**, **23**, and **24**, the ferrule **12** includes a front end face (joint end face) **14** butt-jointed to a ferrule (not shown) of another optical fiber connector (the opposite optical fiber connector), a rear end face **16** which is the opposite end face of the joint end face **14**, optical fiber insertion holes (micro holes) **13** opened in the joint end face **14**, and a boot-receiving hole **17** opened in the rear end face **16**. The ferrule **12** can be formed, for example, as an integrated molded product formed of plastic.

The joint end face **14** of the ferrule **12** may be a vertical face perpendicular to the central axis (substantially matched with the optical axis of the optical fiber **42**) of the optical fiber insertion holes **13**, or may be an inclined face inclined in a predetermined direction corresponding to a ferrule of another optical fiber connector.

The optical fiber insertion holes **13** are formed in the same number as the number of optical fibers in one end portion **42** of the inserted optical fiber **40**. For example, a method of injecting an adhesive into the optical fiber insertion holes **13** to adhere to the bare optical fibers can be simply used as the method of fixing the bare optical fibers which are one end portion **42** of the inserted optical fiber **40** to the ferrule **12**. The optical fiber insertion holes **13** are connected to the boot-receiving hole **17**. A ferrule boot **18** is attached around the optical fiber core **41** and is received in the boot-receiving hole **17**. The ferrule boot **18** is preferably formed of a flexible material such as rubber or elastomer, but the ferrule boot **18** may be formed of a material such as a resin or a metal having low flexibility.

Examples of the number of optical fiber insertion holes **13** (the number of cores) formed in the ferrule **12** include 2, 4, 8, and 12 and depend on the number of cores of the optical fiber core **47**. In the optical fiber connector **110** according to this embodiment, a single-core ferrule may be used as the ferrule **12**.

The optical fiber insertion holes **13** on the joint end face **14** of the multi-core ferrule **12** are arranged in a line to match with the arrangement of optical fibers pinched between the reinforcing members **51** and **54**. The invention is not limited to the constitution in which the arrangement of optical fibers in the ferrule **12** is set to be the same as the arrangement of optical fibers in the splice reinforcing portion **50**, but the arrangement of optical fibers separated for each core between the ferrule **12** and the splice reinforcing portion **50** may be changed.

As shown in FIG. **24**B, a ferrule boot **18** covering the portion of the inserted optical fiber **40** protruding from the ferrule **12** is attached to the ferrule **12**. The pair of reinforcing members **51** and **54** (specifically, the bodies **52** and **55** thereof) includes protrusions serving as boot clamping portions **52***a* and **55***a* at the ends close to the ferrule **12** and the ferrule boot **18** is clamped between the boot clamping portions **52***a* and **55***a*.

Accordingly, both ends of the ferrule boot **18** are tightly held between the ferrule **12** and the pair of reinforcing members **51** and **54**, thereby more satisfactorily preventing the warp or damage of the inserted optical fiber **40**.

A guide pin **15** of which the front end portion protrudes forward from the joint end face **14** is provided to the ferrule **12** for the purpose of the positioning with respect to the ferrule of the opposite optical fiber connector.

The guide pin **15** is inserted into a guide pin insertion hole **15***a* passing through the joint end face **14** and the rear end face **16** and is inserted into a guide pin insertion hole (not shown) formed in the ferrule of another optical fiber connector to suppress the misalignment in the direction along the joint end face **14** (such as the vertical direction in FIG. **24**A, the vertical direction in FIG. **24**B, or an inclined direction obtained by combining the directions) and accurately align the optical fiber connector **110** and the opposite optical fiber connector.

The positioning type relative to the opposite optical fiber connector using the guide pin **15** is called a guide pin positioning type.

As shown in FIG. **24**A, the guide pin insertion holes **15***a* and **15***a* enable the guide pin **15** to detachably be inserted thereto (inserted and pulled out) and is formed in the front-rear direction.

In this embodiment, two guide pin insertion holes **15***a* are formed and are formed on both sides, respectively, of the optical fiber insertion hole **13** through which the inserted optical fiber **40** is inserted.

The guide pins **15** are inserted into the pair of guide pin insertion holes **15***a*.

As shown in FIG. **22**, the guide pin **15** has a substantially tubular cylinder shape and includes a body portion **190** having a tapered front end portion **190***a* and a base end portion **191** formed at the rear end thereof.

The base end portion **191** includes a neck portion **192** extending backward from the rear end of the body portion **190** and a head portion **193** formed at the rear end of the neck portion **192**. The front surface of the head portion **193** serves as a locking end portion **193***a* coming in contact with a front plate portion **177** of a pin clamp **19** to be described later.

The body portion **190**, the neck portion **192**, and the head portion **193** all have a substantially cylindrical shape and the central axis directions thereof are matched with each other.

The neck portion **192** has a diameter smaller than that of the head portion **193**. Hereinafter, the neck portion **192** may be referred to as a small-diameter portion and the head portion **193** may be referred to as a large-diameter portion. The body portion **190** has a diameter larger than that of the neck portion **192**.

As shown in FIGS. **23** and **24**, the body portion **190** is inserted through the guide pin insertion hole **15***a* and the front end portion thereof protrudes forward from the joint end face **14**.

As shown in FIG. **24**A, the base end portion of the guide pin **15** protrudes from the rear end face **16** of the ferrule **12** and the base portion **191** which is the protruding portion is held in the pin clamp **19**.

The optical fiber connector **110** shown in FIG. **23** is of a type (male type) having a guide pin **15**, but may be of a type (female type) not having a guide pin **15** as described later.

As shown in FIGS. **18**, **23**, and **24**, the pin clamp **19** is disposed on the side of the rear end face **16** of the ferrule **12**. The pin clamp **19** is disposed on the front side of the fusion-spliced portion **44**.

As shown in FIGS. **19** to **21**, the pin clamp **19** serves to support the guide pin **15** and is detachably attached to the base end portion **191** of the guide pin **15** protruding from the rear end face **16** of the ferrule **12**.

The pin clamp **19** shown in the drawings is formed of a synthetic resin material and has a substantially U shape having a bottom portion **171** and side wall portions **172** and **172** formed on both sides of the bottom portion **171**. The space surrounded with the bottom portion **171** and the side wall portions **172** and **172** serves as an insertion space **173** through which the inserted optical fiber **40** is inserted (see FIGS. **23** and **24**).

The insertion space **173** can be formed to receive the ferrule boot **18**. That is, by setting the distance between the side wall portions **172** and **172** to be substantially equal to or slightly smaller than the width of the ferrule boot **18**, both edges of the ferrule boot **18** contact the inner surfaces of the side wall portions **172** and **172** to position the ferrule boot.

In the below description, the extending direction of the side wall portions **172**, that is, the upward direction in FIG. **21**, may be referred to as upward (or the height direction) and the opposite direction thereof may be referred to as downward. The vertical direction in FIG. **21** is a direction substantially perpendicular to the formation direction of the guide pin insertion hole **15***a* through the guide pin **15** is inserted.

The side wall portion **172** includes an outer plate portion **175**, an inner plate portion **176** formed with a gap inward from the outer plate portion **175**, a front plate portion **177** formed at a front edge of the bottom portion **171**, and a rear plate portion **178** formed at a rear edge of the bottom portion **171**.

The outer plate portion **175** is substantially vertically upright from the side edge of the bottom portion **171** with respect to the bottom portion **171**.

The inner plate portion **176** is substantially vertically upright with respect to the bottom portion **171** and the space between the outer plate portion **175** and the inner plate portion serves as a reception portion **179** receiving the head portion **193** of the guide pin **15**.

The inner plate portion **176** is formed to be lower than the outer plate portion **175**. The bottom surface **179***a* of the reception portion **179** may be a curved surface along the outer circumference of the head portion **193**.

As shown in FIGS. **19** to **21**, the front plate portion **177** is substantially vertically upright from the front edge of the bottom portion **171** with respect to the bottom portion **171**. Accordingly, the front plate portion **177** is substantially perpendicular to the front-rear direction.

A locking recessed portion **183** is formed downward from the upper edge **177***a* of the front plate portion **177**. The locking recessed portion **183** shown in the drawings has a substantially U shape and the bottom portion **183***a* which is the deepest portion is located to be higher than the bottom surface **179***a* of the reception portion **179**.

As shown in FIG. **21**, since the locking recessed portion **183** is formed downward from the upper edge **177***a*, it can receive the neck portion **192** of the guide pin **15** moving downward.

Since the outer plate portion **175**, the inner plate portion **176**, and the rear plate portion **178** are formed to extend substantially upward, the reception portion **179** surrounded therewith can receive the head portion **193** moving downward.

Accordingly, the neck portion **192** and the head portion **193** of the guide pin **15** can go into and from the locking recessed portion **183** and the reception portion **179** in the vertical direction in FIG. **21**.

In the example shown in the drawings, the locking recessed portion **183** is formed downward (that is, in the direction substantially perpendicular to the formation direction of the guide pin insertion hole **15***a*), but the formation direction of the locking recessed portion **183** is not limited to this direction and may be any direction as long as it is a direction crossing the formation direction of the guide pin insertion hole **15***a*. For example, the formation direction may be a direction inclined by an angle greater than 0° and less than 90° in the vertical direction in FIG. **21**.

As shown in FIGS. **20** and **21**, the width W**1** of the locking recessed portion **183** is larger than the outer diameter of the neck portion **192** of the guide pin **15** and smaller than the outer diameter of the head portion **193**, the locking recessed portion **183** regulates the forward movement of the head portion **193** and regulates the movement of the guide pin **15** in the direction.

That is, as shown in FIG. **20**, when a force toward the front end (downward in FIG. **20**) is applied to the guide pin **15**, a locking end portion **193***a* which is the front face of the head portion **193** comes in contact with the rear face **177***a* of the front plate portion **177**, thereby preventing the forward movement of the head portion **193**. Accordingly, it is possible to prevent the falling of the guide pin **15**.

The rear plate portion **178** is formed substantially vertically upright from the rear edge of the bottom portion **171** with respect to the bottom portion **171**. The outer edge of the rear plate portion **178** reaches the rear edge of the outer plate portion **175**. In the example shown in the drawing, the rear plate portion **178** has substantially the same height as the outer plate portion **175**.

The rear plate portion **178** or the front plate portion **177** can be configured to regulate the backward movement of the guide pin **15**. That is, the rear plate portion **178** or the front plate portion **177** can be configured to prevent the backward movement of the guide pin **15** by bringing the rear face **190***b* of the body portion **190** into contact with the front plate portion **177** or bringing the head portion **193** into contact with the rear plate portion **178**, when a force to the rear side (upward in FIG. **20**) is applied to the guide pin **15**.

As shown in FIG. **20**, a positioning protuberance portion **181** protruding backward is formed on the rear face **178***a* of the rear plate portion **178**.

As shown in FIG. **23**, the positioning protuberance portion **181** serves to prevent the misalignment of the ferrule spring **24** and is inserted into the front end portion of the ferrule spring **24**.

The rear face **178***a* of the rear plate portion **178** serves as a spring seat **20** for accepting an impelling force (pressing force based on elasticity) from the ferrule spring **24**. Accordingly, even when the guide pin **15** is not installed in the ferrule **12**, the pin clamp **19** is attached to the ferrule **12**. The pin clamp **19** can be inserted into and fixed to the ferrule **12** by, for example, irregularity or the like (not shown).

The optical fiber connector **110** described in this embodiment is a multi-core optical fiber connector and the example shown in the drawings is an MPO type optical fiber connector (F13 type multi-core optical fiber connector defined in the JIS C5982, MPO: Multi-fiber Push On). The optical fiber connector applicable to the invention is not limited to the single-core type or the multi-core type.

The housing **11** of the optical fiber connector **110** includes a sleeve-like (tubular) plug frame **21** and a sleeve-like (tubular) stop ring **30** attached to the rear end of the plug frame **21**.

The ferrule **12** is inserted through the opening **22** at the front end of the plug frame **21**.

An engaging claw **33** which can engage with an engaging window **27** formed in the side wall portion of the plug frame **21** is formed in the outer surface of the stop ring **30** so as to integrate the plug frame **21** and the stop ring **30** into a body.

The ferrule spring **24** (impelling means) serves to impel the ferrule **12** forward through the use of the pin clamp **19** and is disposed around the splice reinforcing portion **50**, the front end of the spring **24** is brought into contact with the spring seat **20** at the rear end of the pin clamp **19**, and the rear end of the spring **24** is brought into contact with the spring seat **31** at the front end of the stop ring **30**.

When the joint end face **14** of the ferrule **12** is jointed to a ferrule of another optical fiber connector, the ferrule **12** is guided in the opening **22** and pushed backward to contract the ferrule spring **24**, an appropriate force acts between the joint end face **14** of the ferrule **12** and a joint end face of a ferrule of another optical fiber connector, thereby bringing the joint end faces into close contact with each other. When the joint between the ferrule **12** and the ferrule of another optical fiber connector is released, the ferrule spring **24** is stretched and the ferrule **12** moves in the opening **22** and is restored to the original position.

An engaging portion **23** used for the MPO type connector plug to engage with an engaging claw (not shown) of an MPO type connector adaptor or a receptacle is disposed on both sides (both side in the vertical direction in FIG. **23**A) in the width direction of the plug frame **21**. A coupling **25** is disposed on the outer circumference of the plug frame **21**, and a pair of coupling springs **26** and **26** is received between the outer circumferential surface of the plug frame **21** and the inner circumferential surface of the coupling **25**. Accordingly, the coupling **25** can move forward and backward relative to the plug frame **21** with the stretching and contracting of the coupling springs **26** and **26**. The engaging portion **23** or the coupling **25** has the same constitution as defined in the JIS or the like as the MPO type connector plug.

When the invention is applied to different types of optical fiber connectors, the constituents required for the joint (connector joint) of the optical fiber connectors are installed in the ferrule or the housing.

A through-hole **32** passing in the front-rear direction (the lateral direction in FIG. **23**) along the length direction of the optical fiber is formed in the stop ring **30**. The cross-sectional shape (the sectional shape in the plane perpendicular to the length direction of the optical fiber) of the through-hole **32** has at least a size which can receive the shape of the cross-sectional shape of the splice reinforcing portion **50**. Accordingly, when the stop ring **30** is pushed in toward the plug frame **21** from the rear side of the splice reinforcing portion **50** in a state where the ferrule **12** is inserted into the opening **22** of the plug frame **21**, the stop ring **30** is prevented from interfering with the splice reinforcing portion **50** (hindering the push thereof). When the stop ring **30** is pushed in toward the plug frame **21** from the rear side of the splice reinforcing portion **50**, the engaging claw **33** is drawn into the splice reinforcing portion **50** just before the engaging claw **33** reaches the engaging window **27**. Accordingly, on the back surface side of the engaging claw **33**, a groove **32***a* is formed in the inner surface of the through-hole **32**, thereby avoiding the interference of the splice reinforcing portion **50** with the back surface of the engaging claw **33**.

An external screw **34** is formed on the outer circumferential surface of the rear end portion of the stop ring **30**. An internal screw **36** formed on the inner circumferential surface of the screw ring **35** can be fastened to the external screw **34**. The front end portion of the tensile fiber **49** of the external optical fiber **45** can be pinched and fixed between the external screw **34** and the internal screw **36**. The screw ring **35** includes an opening **37** at the rear end thereof, and a part of the tensile fiber **49** of the external optical fiber **45** and the optical fiber core **47** is inserted into the opening **37**. The cross-sectional shape (the sectional shape in the plane perpendicular to the length direction of the optical fiber) of the opening **37** preferably has a certain opening size so as to avoid the contact of the tensile fiber **49** with the splice reinforcing portion **50**.

A boot **65** for an external optical fiber for protecting the external optical fiber **45** is attached to the outer circumferential surface of the screw ring **35**. The boot **65** is generally formed of a flexible material such as rubber or elastomer. In this embodiment, a protective tube **66** is attached around the sheath **48** of the external optical fiber **45** and an annular locking portion **67** having a large diameter at the front end portion of the tube **66** is inserted into the boot **65**.

The sequence of assembling the housing or the like is not particularly limited, but the following sequence can be employed as an example.

As an advance preparation before the fusion splice, the ferrule spring **24**, the stop ring **30**, the screw ring **35**, the external optical fiber boot **65**, and the protective tube **66** are made to pass around the external optical fiber **45**. These components are preferably arranged on the rear side (the right side in FIG. **23**) so as not to interfere with the fusion splice.

The bare optical fibers **43** and **46** are fusion-spliced and the fusion-spliced portion **44** is pinched and reinforced between the pair of reinforcing members **51** and **54** in the splice reinforcing portion **50**.

As shown in FIGS. **19** and **21**, the locking recessed portion **183** of the pin clamp **19** is formed downward and thus can cause the neck portion **192** of the guide pin **15** to go into and away from the vertical direction.

Accordingly, as shown in FIG. **18**, by upward moving the pin clamp **19** indicated by a virtual line, it is possible to fit the neck portion **192** of the guide pin **15** into the locking recessed portion **183**. At this time, the head portion **193** is received in the reception portion **179**.

Accordingly, the pin clamp **19** is disposed at the rear end of the ferrule **12** in the state where the base end portion **191** of the guide pin **15** is held therein.

As shown in FIGS. **20** and **21**, since the width W1 of the locking recessed portion **183** is smaller than the outer diameter of the head portion **193**. Accordingly, when the forward force (downward in FIG. **20**) is applied to the guide pin **15**, the locking end portion **193***a* which is the front face of the head portion **193** comes in contact with the rear face **177***a* of the front plate portion **177**, thereby stopping the forward movement of the head portion **193**. Accordingly, the forward movement of the guide pin **15** is regulated.

When a backward (upward in FIG. **20**) force is applied to the guide pin **15**, the rear face **190***b* of the body portion **190** comes in contact with the front plate portion **177** or the head portion **193** comes in contact with the rear plate portion **178**, thereby regulating the backward movement of the guide pin **15**.

The plug frame **21** is attached from the front side (the left side in FIG. **23**) of the ferrule **12** to dispose the ferrule **12** in the opening **22** of the plug frame **21**, the stop ring **30** is pushed into the plug frame **21** to cause the engaging claw **33** to engage with the engaging window **27**, and the ferrule spring **24** is received along with the ferrule **12** and the splice reinforcing portion **50**. The coupling **25** may be attached to the plug frame **21** in advance or may be attached thereto after the coupling **25** is attached to the stop ring **30**.

The front end portion of the tensile fiber **49** is placed on the external screw **34** of the stop ring **30** and the internal screw **36** of the screw ring **35** is fastened to the external screw **34** to fix the front end portion of the tensile fiber **49**. When the front end portion of the tensile fiber **49** extends over the outer circumference of the plug frame **21**, the tensile fiber is cut out if necessary. The boot **65** is attached to the stop ring **30**. The optical fiber connector **110** shown in FIG. **23** can be assembled through this sequence.

When the external optical fiber does not include a tensile fiber, the internal screw **36** of the screw ring **35** is fastened to the external screw **34** of the stop ring **30** to integrate the housing into a body, without pinching the tensile fiber.

The optical fiber connector **110** shown in FIG. **23** is of a type (male type) having a guide pin **15**, but may be of a type (female type) not having a guide pin **15**.

The sequence of detaching the guide pin **15** from the optical fiber connector **110** of the type (male type) shown in FIG. **23** to acquire the optical fiber connector **110** of the type (female type) not having the guide pin **15** will be described below with reference to FIGS. **26** to **28**.

In the reverse sequence of the above-mentioned sequence, the plug frame **21** is detached to expose the ferrule **12** and the pin clamp **19**.

As described above, the locking recessed portion **183** of the pin clamp **19** can allow the neck portion **192** of the guide pin **15** to go into and from the locking recessed portion in the vertical direction in FIG. **21**. Accordingly, as shown in FIGS. **26** and **27**, when the pin clamp **19** is moved downward, the neck portion **192** is pulled out of the locking recessed portion **183**.

Accordingly, the guide pin **15** can move in the length direction and can be pulled out toward the front end.

As shown in FIG. **28**, the pin clamp **19** is moved upward after pulling out the guide pin **15**, and then is disposed at the rear end of the ferrule **12**. By attaching the plug frame **21** again, it is possible to obtain the optical fiber connector **110** of the type (female type) not having the guide pin **15**.

The optical fiber connector **110** not having the guide pin **15** has the same constitution as the optical fiber connector **110** shown in FIG. **23**, except that the guide pin **15** is not provided. In such a type of optical fiber connector **110**, the guide pin insertion hole **15***a* serves as an insertion hole into which a guide pine of the opposite optical fiber connector is inserted.

When it is intended to change the optical fiber connector **110** of the type (female type) not having the guide pin **15** to the type (male type) having the guide pin **15**, the guide pin **15** has only to be attached to the ferrule **12** in the opposite sequence of the above-mentioned sequence.

In the optical fiber connector **110**, the pin clamp **19** includes the locking recessed portion **183** and the locking recessed portion **183** can allow the neck portion **192** of the guide pin **15** to go into and from the locking recessed portion in the direction substantially perpendicular to the guide pin insertion hole **15***a*. Accordingly, by moving the pin clamp **19** in the direction, it is possible to release the movement regulation in the length direction of the guide pin **15** and to separate the guide pin **15**.

Therefore, the type (male type) having the guide pin **15** and the type (female type) not having the guide pin **15** can be easily switched to each other, thereby improving the workability on the splicing site.

In separation of the guide pin **15**, since it is not necessary to move the pin clamp **19** backward, the fusion-spliced portion **44** of the inserted optical fiber **40** and the external optical fiber **45** is not adversely influenced. Therefore, it is not necessary to guarantee a space for movement of the pin clamp **19** between the ferrule **12** and the fusion-spliced portion **44**, thereby reducing the size in the length direction of the optical fiber connector **110**.

Since the pin clamp **19** includes the locking recessed portion **183** to which the base end portion **191** of the guide pin **15** is locked, it is possible to prevent the guide pin **15** from falling out toward the front end.

In this embodiment, the fusion-spliced portion **44** of the inserted optical fiber **40** and the external optical fiber **45** is pinched between a pair of reinforcing members **51** and **54** in the splice reinforcing portion **50**, but the invention is not limited to this constitution. A constitution in which the fusion-spliced portion **44** is reinforced with a known reinforcing sleeve may be employed.

Another splicing method such as a method (mechanical splice method) of butt-jointing optical fibers of a pair of elements of a clamp unit may be used for the splicing of the inserted optical fiber **40** and the external optical fiber **45**.

FIGS. **29** and **30** show another example of the pin clamp and the pin clamp **119** shown in the drawings is different from the pin clamp **19** shown in FIGS. **19** to **21**, in that an extension **182** having a holding protrusion **184** is formed in the front plate portions **177** and **177**.

The extension **182** is formed at the upper edges of the front plate portions **177** and **177** so as to extend upward from the further inner position than the locking recessed portion **183**.

The holding protrusion **184** is formed at the inner edge of the extension **182** so as to protrude inward (in a direction in which both holding protrusions get closer to each other).

As shown in FIG. **30**, since the distance between the front ends of the holding protrusions **184** and **184** is smaller than the width of the ferrule boot **18**, the holding protrusion **184** can regulate the upward movement (outward movement) of the ferrule boot **18** in the insertion space **173**. Accordingly, the pin clamp **119** can be prevented from falling out of the ferrule boot **18**.

The top surface **184***a* of the holding protrusion **184** is an inclined face slowly going down toward the protruding direction (inward). Accordingly, when the ferrule boot **18** is inserted into the insertion space **173**, the ferrule boot **18** presses the top face **184***a* outward to move the holding protrusions **184** outward with the warping deformation of the front plate portions **177**, thereby enabling the insertion of the ferrule boot **18**.

Hereinafter, a cap-attached optical fiber connector, an optical fiber connector assembling method, and an optical fiber connector cap according to embodiments of the invention will be described with reference to the accompanying drawings.

Third Embodiment

A third embodiment of the invention will be described below.

FIG. **31** shows a cap-attached optical fiber connector **210**A according to this embodiment.

In the cap-attached optical fiber connector **210**A, an optical fiber connector cap **150** (hereinafter, may be simply referred to as a cap) is detachably attached to a front end portion (an end portion of the side on which a ferrule **211** is disposed) of an optical fiber connector **210** assembled to the terminal of an optical fiber cord **2** (optical transmission medium).

In FIGS. **31**, **32**A, and **32**B, the left side in the cap-attached optical fiber connector **210**A and the optical fiber connector **210** is defined as a front side and the right side is defined as a rear side.

Hereinafter, FIGS. **32**A and **32**B may be comprehensively referred to as "FIG. **32**". Similarly, FIGS. **40**A and **40**B may be comprehensively referred to as "FIG. **40**", FIGS. **42**A and **42**B may be comprehensively referred to as "FIG. **42**", FIGS. **43**A and **43**B may be comprehensively referred to as "FIG. **43**", and FIGS. **45**A and **45**B may be comprehensively referred to as "FIG. **45**".

The optical fiber connector **210** shown in FIG. **31** is a single-core optical fiber connector.

The optical fiber connector **210** is a so-called site-assembled optical fiber connector.

As shown in FIGS. **31**, **32**A, and **32**B, the optical fiber connector **210** schematically includes a ferrule **211** having a structure in which a flange portion **211***b* protrudes on the outer circumference of a capillary member **211***a*, an inserted optical fiber **212** which is a short optical fiber inserted into and fixed to the ferrule **211** (specifically, the capillary member **211***a*), a sleeve-like housing **214** receiving an optical-fiber-attached ferrule **213** including the ferrule **211** and the inserted optical fiber **212** inserted into and fixed to the ferrule **211** (specifically, the capillary member **211***a*), a spring **215** that is received in the housing **214** and that elastically impels the optical-fiber-attached ferrule **213** to the front side (hereinafter, also referred to as a connector front side) relative to the housing **214**, and a screwed ring member **216** screwed to a tensile member fixing tube **214***a* (to be described later) which is a rear end portion of the housing **214** opposite to the front end portion in which the ferrule **211** is disposed.

The optical fiber connector **210** further includes a boot **217** externally inserted onto the screwed ring member **216** and disposed to extend backward from the screwed ring member **216**.

As shown in FIG. **38**, in the optical fiber connector **210**, a sleeve-like grin **218** (coupling) may be externally inserted and attached to the housing **214**. The grip **218** is disposed in the housing **214** to slide within a movable range in the front-rear direction.

In FIG. **38**, the optical fiber connector having the grip **218** disposed therein is referenced by reference sign **210**B.

In the housing **214**, a sleeve-like stop ring **142** is inserted into and fixed to the rear end portion of a sleeve-like plug frame **141** to integrate them into a body. The stop ring **142** is disposed to extend backward from the plug frame **141**. The rear end portion of the stop ring **141** located in the back of the plug frame **141** serves as the tensile member fixing tube **214***a* of the housing **214**.

The tensile member fixing tube **214***a* has an external screw **214***b* (screw portion) formed on the outer circumference thereof, and the screwed ring member **216** having an internal screw **216***a* which can be screwed to the external screw **214***b* can be screwed thereto from the rear side of the tensile member fixing tube **214***a*, as shown in FIG. **31**.

Hereinafter, the tensile member fixing tube **214***a* is also referred to as a screwed tube.

A ferrule, a plug frame, and a grip of a single-core optical fiber connector (plug) such as an SC type optical fiber connector (F04 type optical fiber connector defined in the JIS C5973; SC: Single fiber Coupling optical fiber connector) and an MU type optical fiber connector (F14 type optical fiber connector defined in the JIS C5983, MU: Miniature-Unit coupling optical fiber connector) can be employed as the ferrule **211**, the plug frame **141**, and the grip **218**.

The inserted optical fiber **212** of the optical-fiber-attached ferrule **213** includes a rear extension **212***c* which is a portion extending to the rear end opposite to the joint end face **211***c* (front end face) for butt joint which is a front end of the capillary member **211***a* of the ferrule **211**. The inserted optical fiber **212** is inserted into and fixed to the capillary member **211***a* of the ferrule **211** in a state where the end face of the end portion (front end portion) opposite to the rear extension **212***c* is arranged on the polished joint end face **211***c* of the end portion of the capillary member **211***a*.

As shown in FIG. **31**, in the optical fiber connector **210** assembled to the terminal of the optical fiber cord **2**, a spliced portion **3** where the end portion (the rear end portion of the inserted optical fiber **212**) of the rear extension **212***c* of the inserted optical fiber **212** is optically spliced to the front end portion of an optical fiber **2***a* drawn out of the terminal of the optical fiber cord **2** is received in the housing **214**.

The optical fiber **2***a* of the optical fiber cord **2** is a single-core coated optical fiber in which a bare optical fiber **2***d* is coated with a resin coating material **2***e* (hereinafter, also simply referred to as a coating material) so as to cover the outer circumference thereof and to integrate into a body.

On the other hand, the inserted optical fiber **212** is a single-core coated optical fiber (specifically, an optical fiber core) from of which both ends a bare optical fiber **2***a* is drawn out, for example, as shown in FIG. **35**. The inserted optical fiber **212** is bonded and fixed to the ferrule **211** (specifically, the capillary member **211***a*) with an adhesive disposed in a fiber hole **211***d* in a state where one of both protruding portions of a coated portion coated with a coating material **12***b* out of the bare optical fiber **12***a* is inserted into a positioning hole **211***da* which is a front part (on the side of the joint end face **211***c*) of the fiber hole **211***d* penetrating the capillary member **211***a* of the ferrule **211** and which has an opening in the joint end face **211***c* and the coated portion is inserted into a coated portion receiving hole **211***d***2** which is a rear part of the fiber hole **211***d* about the positioning hole **211***d***1** and which has a diameter larger (an inner diameter larger) than that of the positioning hole **211***d***1**.

The optical fibers **2***a* and **212** are a single-core optical fiber core herein, but for example, an optical fiber wire may be employed.

The inserted optical fiber **212** may be a bare optical fiber all over the length.

As shown in FIG. **35**, the coated portion of the inserted optical fiber **212** has a part extending backward from the ferrule **211**.

As shown in FIG. **35**, the spliced portion **3** is a fusion-spliced portion in which the rear end of the inserted optical fiber **212** of the optical-fiber-attached ferrule **213** and the front end of the optical fiber **2***a* extending from the terminal of the optical fiber cord **2** are fusion-spliced. Hereinafter, when the spliced portion **3** indicates the fusion-spliced portion, it may be referred to as a fusion-spliced portion.

The fusion-spliced portion **3** is specifically, a fusion-spliced portion in which the bare optical fiber drawn out from the rear end portion of the inserted optical fiber **212** and the bare optical fiber **2***d* drawn out from the front end portion of the optical fiber **2***a* extending from the terminal of the optical fiber cord **2** are fusion-spliced.

A fusion reinforcing portion (spliced point reinforcing portion) incorporating a reinforcing member (not shown) covering the fusion-spliced portion **3** to the fusion-spliced portion **3** as a body and reinforcing the fusion-spliced portion is received in the housing **214** of the optical fiber connector **210**.

In the optical fiber connector **210**, a part, which extends from a sheath **2***c*, of a fiber-like tensile member **2***b* (hereinafter, also referred to as a tensile fiber) longitudinally added to the optical fiber **2***a* and received along with the optical fiber **2***a* in the resin sheath **2***c* (external sheath) of the optical fiber cord **2** is pinched and fixed between the outer circumferential surface of the screwed tube **214***a* at the rear end of the housing **214** and the inner circumferential surface of the screwed ring member **216** screwed to the screwed tube **214***a*, whereby the optical fiber cord **2** is detained relative to the housing **214**.

A cap **150** will be described below.

As shown in FIGS. **31**, **32**A, and **32**B, the cap **150** has a constitution in which a hooking protrusion **152** (tensile member detaining portion) used to detain the tensile fiber **2***b* extending from the terminal of the optical fiber cord **2** in the work of assembling the optical fiber connector **210** to the terminal of the optical fiber cord **2** protrudes from the outer surface of a body **151** (hereinafter, also referred to as a cap body) of a bottomed cylinder which is detachably externally inserted onto the front end portion (the front end portion of the plug frame **141**) of the housing **214** of the optical fiber connector **210**.

The cap body **151** of the cap **150** shown in the drawings includes a bottomed cylinder of which one end in the axis direction of a tubular body portion **151***a* which can be externally inserted onto the front end portion of the housing **214** of the optical fiber connector **210** is blocked by an end wall **151***b*, and is externally inserted onto the front end portion of the housing **214** so as to be attached to and detached from the housing.

The hooking protrusion **152** protrudes to be inclined about the axis line of the tubular body portion **151***a* so that as it goes from the tubular body portion **151***a* of the cap body **151** to the front end blocked by the end wall **151***b* of the cap body **151**, the distance from the outer circumferential surface of the tubular body portion **151***a* increases.

In the cap **150** shown in the drawings, the hooking protrusions **152** protrude from both sides with the axis line of the tubular body portion **151***a* of the cap body **151** interposed therebetween.

The cap **150** is a plastic molded product and can be produced at a low cost.

A method of assembling the optical fiber connector **210** to the terminal of the optical fiber cord **2** (an optical fiber connector assembling method) will be described below.

First, as shown in FIG. **35**, a fusion-splicing and reinforcing step (fiber splicing step) of fusion-splicing the rear end of the inserted optical fiber **212** of the optical-fiber-attached ferrule **213** assembled in advance to the front end of the optical fiber **2***a* extending from the terminal of the optical fiber cord **2** and assembling a splice reinforcing portion (spliced portion reinforcing portion) for reinforcing the fusion-spliced portion formed by the fusion splice by the use of a reinforcing member **3** is performed.

For example, a reinforcing sleeve **4** shown in FIGS. **36** and **37** can be suitably used as the splice reinforcing portion.

As shown in FIGS. **36** and **37**, the reinforcing sleeve **4** includes a heat-shrinkable tube **4***a* and a thermoplastic resin layer **4***b* disposed along the inner surface thereof, and further includes a rod-like tensile member **4***c* (metal rod) inserted over the whole length in the length direction (axis line direction) of the heat-shrinkable tube **4***a* with the same thickness as the heat-shrinkable tube **4***a*.

In assembling the fusion-spliced portion using the reinforcing sleeve **4**, as shown in FIG. **35**, the inserted optical fiber **212** and the optical fiber **2***a* of the optical fiber cord **2** are fusion-spliced, the reinforcing sleeve **4** externally inserted onto the optical fiber cord **2** in advance is moved to the ferrule **211** and covers the fusion-spliced portion **3**, the rear extension **212***c* of the inserted optical fiber **212**, and the portion, which extends from the terminal of the optical fiber cord **2**, of the optical fiber **2***a* of the optical fiber cord **2**, as shown in FIG. **37**, and the reinforcing sleeve **4** is heated in this state to melt a thermoplastic resin forming the thermoplastic resin layer **4***b* and to thermally contract the heat-shrinkable tube **4***a*. By cooling (for example, cooling with air), the thermoplastic resin in the molted state is solidified. Accordingly, the fusion-spliced portion **3** is embedded in the solidified thermoplastic resin, and the heat-shrinkable tube **4***a*, the thermoplastic resin therein, and the fusion-spliced portion **3** are integrated into a body, whereby it is possible to assemble the fusion splice reinforcing portion in which the fusion-spliced portion **3** is reinforced with the heat-shrinkable tube **4***a*, the thermoplastic rein, and the rod-like tensile member **4***c*.

The heat-shrinkable tube **4***a* is formed of a heat-shrinkable resin and, for example, polyolefin contracting at 100° C. to 160° C. can be used.

A hot-melt resin (hot-melt adhesive) can be suitably used as the thermoplastic resin forming the thermoplastic resin layer **4***b*. Examples of the hot-melt resin include ethylene-vinyl acetate copolymer (EVA), polyethylene, polyisobutylene, polyamide, and ethylene-ester acrylate copolymer. It is preferable that the thermoplastic resin be softened at the contraction temperature of the heat-shrinkable tube **4***a*. The softening temperature is, for example, in the range of 100° C. to 160° C.

In FIG. **37**, one end in the length direction of the reinforcing sleeve **4** is externally inserted onto a rear end tube **211***e* at the rear end of the ferrule **211**, and the heat-shrinkable tube **4***a* is fixed to the rear end tube **211***e* at the rear end of the ferrule **211** when the reinforcing sleeve **4** is heated to assemble the fusion splice reinforcing portion, whereby the ferrule with the fusion splice reinforcing portion in which the fusion splice reinforcing portion is integrated to the rear side of the ferrule **211** is assembled. However, the invention is not limited to this constitution, but the reinforcing sleeve **4** may be disposed at a position separated backward (toward the optical fiber cord **2**) from the ferrule **211** and the fusion splice reinforcing portion not integrated to the ferrule **211** may be assembled at the position separated backward from the ferrule **211**.

The inserted optical fiber **212** extends backward from the rear end tube **211***e* through the inside of the rear end tube **211***e*.

When the fusion splicing and reinforcing step is ended, as shown in FIG. **32**A, a housing assembling step of fitting the stop ring **142** to the plug frame **141** to assemble the housing **214** and receiving the optical-fiber-attached ferrule **213**, the fusion splice reinforcing portion, and the spring **215** (coil spring) in the housing **214** is performed.

In the housing assembling step, the spring **215** and the stop ring **142** externally inserted onto the optical fiber cord **2** in advance is moved toward the ferrule **211**, the ferrule **211**, the fusion splice reinforcing portion, the spring **215**, and the stop ring **142** are inserted into the sleeve-like plug frame **141** from the rear end, and the engaging claw **142***b* protruding from the outer circumference of the stop ring **142** is locked to the engaging recessed portion **141***a* formed in the inner surface of the rear end portion of the plug frame **141**, whereby the front sleeve portion **142***a* located in the front of the screwed tube **214***a* of the stop ring **142** is fitted to the plug frame **141**.

As a result, the stop ring **142** is fixed to the plug frame **141**, and the ferrule **211**, the fusion splice reinforcing portion, and the spring **215** are received in the sleeve-like housing **214** in which the plug frame **141** and the stop ring **142** are integrated into a body.

In the ferrule **211**, the capillary member **211***a* is inserted into a front end opening **141***c* guaranteed inside a front end convex wall **141***b* protruding on the inner circumference of the front end portion of the plug frame **141** so as to be movable in the axis line direction of the plug frame **141** and is received in the front end portion of the housing **214** so as to be movable in the axis line direction of the housing **214**. By bringing the flange portion **211***b* into contact with the front end convex wall **141***b* inside the housing **214**, the capillary member is prevented from falling out forward from the housing **214**.

The spring **215** is locked so as not to fall out backward from the stop ring **142** by the spring receiving wall **142***c* protruding in the rear end portion of the stop ring **142**. In the ferrule **211**, the flange portion **211***b* is disposed at the position where it comes in contact with the front end convex wall **141***b* of the plug frame **141** with the elastic impelling force of the spring **215** and can be pushed into the rear side of the housing **214** against the elastic impelling force of the spring **215**.

When the housing **214** is assembled in the housing assembling step, as shown in FIG. **32**A, a tensile member fixing step of fitting the cap body **151** of the cap **150** to the front end portion of the housing **214** to attach the cap **150** to the housing **214**, hooking and detaining the tensile fiber **2***b* extending from the optical fiber cord **2** to and in the hooking protrusion **152** of the cap **150**, and screwing the screwed ring member **216** to the screwed tube **214***a* at the rear end of the housing **214** (FIG. **32**B) to fix the tensile fiber **2***b* to the screwed tube **214***a* is carried out.

In the housing assembling step, when the assembling of the housing **214** is completed, the terminal of the optical fiber cord **2** is disposed at a position separated backward from the housing **214**.

In the tensile member fixing step, the front end portion of the tensile fiber **2***b* being drawn out from the terminal of the optical fiber cord **2** along with the optical fiber **2***a* in advance and extending from the terminal of the optical fiber cord **2** is attached to and detained in the hooking protrusion **152** of the cap **150** attached to the front end portion of the housing **214**, for example, by winding, binding, or the like.

In this specification, the winding or the binding is considered to correspond to the "hooking" of the tensile fiber **2***b* on the hooking protrusion **152** of the cap **150**.

For example, as shown in FIG. **34**, in the tensile fiber **2***b* extending from the terminal of the optical fiber cord **2**, a loop portion **2***g* in which the front end portion thereof is formed in a loop and a knot **2***f* causing the tensile fiber **2***b* to hold the loop portion **2***g* may be formed and then the loop portion **2***g* may be externally inserted onto and hooked on the hooking protrusion **152**.

As described above, the hooking protrusion **152** protrudes to be inclined about the axis line of the tubular body portion **151***a* so that as it goes from the tubular body portion **151***a* of the cap body **151** to the front end blocked by the end wall **151***b* of the cap body **151**, the distance from the outer circumferential surface of the tubular body portion **151***a* increases. Accordingly, there is an advantage that it is difficult to allow the tensile fiber **2***b* hooked on the hooking protrusion **152** by winding, binding, or the like to fall out of the hooking protrusion **152**.

The tensile fiber **2***b* is hooked on and fixed to the hooking protrusion **152**, whereby tension is applied to the part extending between the terminal of the optical fiber cord **2** and the hooking protrusion **152**.

For example, aramid fiber can be suitably used for the tensile fiber **2***b* but, for example, glass fiber and carbon fiber may be used in addition to the aramid fiber.

A plurality of tensile fibers **2***b* are received in the sheath **2***c* of the optical fiber cord **2**. In this case, in detaining the tensile fibers **2***b* in the hooking protrusion **152** of the cap **150** attached to the front end portion of the housing **214** by the hooking, specifically, a plurality of tensile fibers **2***b* extending from the terminal of the optical fiber cord **2** are partitioned into two parts with the optical fiber **2***a* interposed therebetween to form two tensile fiber sets **2***h* with substantially the same thickness and the front end portions of the tensile fiber sets **2***h* are hooked on two hooking protrusions **152** of the cap **150**, respectively.

When the detainment of the tensile fibers **2***b* in the hooking protrusions **152** of the cap **150** by the hooking is completed, the screwed ring member **216** externally inserted onto the optical fiber cord **2** in advance is moved toward the housing **214** and the screwed ring member **216** is screwed to the outer circumference of the screwed tube **214***a* at the rear end portion (the rear end portion of the stop ring **142**) of the housing **214**, as shown in FIG. 32B.

As described above, the terminal of the optical fiber cord **2** is disposed at the position separated backward from the housing **214**. Accordingly, when the screwed ring member **216** is screwed to the outer circumference of the screwed tube **214***a*, two tensile fiber sets **2***h* extending forward from the terminal of the optical fiber cord **2** through the vicinity of the external screw **214***b* of the screwed tube **214***a* can be pinched and fixed between the outer circumferential surface of the screwed tube **214***a* and the inner circumferential surface of the screwed ring member **216**. The tensile fiber sets **2***h* are specifically pinched between the external screw **214***b* of the screwed tube **214***a* and the internal screw **216***a* of the screwed ring member **216** and thus can be strongly fixed to the rear end portion of the housing **214**.

When the tensile member fixing step is ended, the parts of the tensile fiber sets **2***h* from the position at which they are fixed to the housing **214** by the use of the screwed ring member **216** to the cap **150** are removed, and the sleeve-like boot **217** externally inserted onto the optical fiber cord **2** in advance is moved toward the housing **214** and externally fitted and attached to the screwed ring member **216** (see FIG. **31**). Accordingly, it is possible to totally assemble the optical fiber connector **210**.

Since the cap **150** is attached to the front end portion of the assembled optical fiber connector **210**, it is possible to obtain a cap-attached optical fiber connector **210**A at the same time as assembling the optical fiber connector **210**. Since the cap **150** attached to the optical fiber connector **210** covers the joint end face **211***c* at the front end of the capillary member **211***a* of the ferrule **211** of the optical fiber connector **210** by the use of the cap body **151**, the cap can be made to function as a protective cover protecting the joint end face **211***c* of the ferrule **211** by holding the state where it is attached to the optical fiber connector **210**.

The terminal of the optical fiber cord **2** is disposed in an inner hole **217***a* penetrating the boot **217** disposed to extend backward from the screwed ring member **216**.

Since the tensile fibers **2***b* extending from the terminal of the optical fiber cord **2** are fixed to the screwed tube **214***a* at the rear end of the housing **214** through the use of the screwed ring member **216**, the terminal is detained without falling out to the rear side of the connector from the sleeve-like boot **217** disposed to extend backward from the screwed ring member **216**.

The grip **218** shown in FIG. **38** can be attached to the outside of the housing **214** so as to slide within a movable range in the front-rear direction guaranteed by externally inserting the grip to the housing **214** from the front side (connector front side) of the optical fiber connector **210**.

When it is intended to install the grip **218** in the optical fiber connector **210** with the cap **150** attached thereto, that is, the cap-attached optical fiber connector **210**A shown in FIG. **31**, having been completely assembled to the terminal of the optical fiber cord **2**, the cap **150** is detached from the optical fiber connector **210** and the grip **218** is externally inserted onto the housing **214** from the front side of the optical fiber connector **210**.

As described above, in the course of assembling the optical fiber connector **210** to the terminal of the optical fiber cord **2**, by attaching the cap **150** to the housing **214** in the step of assembling the housing **214**, the front end portions of the tensile fiber sets **2***h* extending from the terminal of the optical fiber cord **2** can be hooked on (wound on or bound to) and detained in the hooking protrusion **152** of the cap **150** and thus tension can be applied to the tensile fiber sets **2***h*.

Accordingly, without using a conventional swaging tool, the work of fixing the tensile fiber sets **2***h* to the rear end of the housing **214** can be carried out in the state where tension is applied to the tensile fiber sets **2***h*.

Fourth Embodiment

A fourth embodiment of the invention will be described below.

As shown in FIG. **39**, an optical fiber connector **20** according to this embodiment is different from the optical fiber connector **210** according to the third embodiment, in that the ferrule **211** directly attached to the front end of the optical fiber **2***a* drawn out from the terminal of the optical fiber cord

2 instead of the optical-fiber-attached ferrule **213** described in the third embodiment is received in the housing **214**.

The constitutions other than the constitution in which the ferrule **211** directly attached to the front end of the optical fiber **2**a is received in the housing **214** are equal to those of the optical fiber connector **210** according to the third embodiment.

The front end of the optical fiber **2**a drawn out from the terminal of the optical fiber cord **2** is inserted into the ferrule **211**. As shown in FIG. **41**, the optical fiber **2**a is attached and fixed to the ferrule **211** by inserting the bare optical fiber **2**d drawn out from the front end thereof into the positioning hole **211**d**1** (see FIG. **35**) of the fiber hole **211**d of the ferrule **211** and inserting the front end portion of the coated portion coated with the coating material **2**e into the coated portion receiving hole **211**d**2**. The joint end face **211**c of the ferrule **211** is polished, for example, after the optical fiber **2**a is inserted and fixed.

The optical fiber connector **20** is assembled by attaching the ferrule **211** to the front end of the optical fiber **2**a, assembling the housing **214** to receive the ferrule **211** and the spring **215** as shown in FIG. **40**A, fixing the tensile fiber sets **2**h of the optical fiber cord **2** to the screwed tube **214**a of the rear end portion of the housing **214** through the sequence of the tensile member fixing step described in the third embodiment as shown in FIGS. **40**A and **40**B, and then externally inserting and fixing the tensile fiber sets to the screwed ring member **216** attached to the rear end portion (the screwed tube **214**a) of the housing **214**.

As shown in FIGS. **40**A and **40**B, since the work of fixing the tensile fiber sets **2**h of the optical fiber cord **2** to the screwed tube **214**a of the rear end portion of the housing **214** is performed in the state where the tensile fiber sets **2**h are hooked on and detained in the hooking protrusions **152** protruding from the cap body **151** of the cap **150** attached to the front end portion of the housing **214** through the sequence of the tensile member fixing step described in the third embodiment, it is possible to obtain a cap-attached optical fiber connector **20**A in which the cap **150** is attached to the front end portion of the optical fiber connector **20** at the same time as the assembly of the optical fiber connector **20** is completed.

Fifth Embodiment

A fifth embodiment of the invention will be described below.

The invention may be applied to the assembling of the optical fiber connector to the terminal of a multi-core optical fiber cord (optical transmission medium).

FIG. **42** shows an optical fiber connector **100** according to this embodiment and FIG. **43** shows an important part of the optical fiber connector **100**. The optical fiber connector **100** has a constitution in which the other end portion **43** of an inserted optical fiber **40** of which one end portion **42** is fixed to a ferrule **280** is fusion-spliced to a front end portion **46** of an external optical fiber **45** and a spliced point reinforcing portion **50** in which the fusion-spliced portion **44** is pinched and reinforced between a pair of reinforcing members **51** and **54** is received in a housing or the like.

In the following description, in order to distinguish both sides in the length direction (the lateral direction in FIG. **42**) of an optical fiber, the side which a joint end face **281** of the ferrule **280** faces (the left side in FIG. **42**) may be referred to as "front side" and the opposite side (the right side in FIG. **42**) may be referred to as "rear side". The front side is also referred to as a "front end" and the opposite side (the right side in FIG. **42**) thereof is also referred to as a "rear end".

An external optical fiber **45** is formed of an optical transmission medium such as an optical fiber cord or an optical fiber cable having an optical fiber. In this embodiment, the external optical fiber **45** is an optical fiber cord including a multi-core optical fiber core **47** including an optical fiber tape core in which a plurality optical fibers (optical fiber wires, which are not shown) are arranged in parallel in the lateral direction perpendicular to the length direction thereof, a tubular sheath **48** (outer shell, externally-inserted film) surrounding the multi-core optical fiber core **47**, and a tensile fiber **49** received between the optical fiber core **47** and the sheath **48**.

In the front end portion **46** of the external optical fiber **45**, the resin coating of the optical fiber core **47** and the resin coating of the optical fiber wires are removed and each of a plurality of bare optical fibers (parts of core and clad) are separated.

Examples of the number of bare optical fibers **46** (the number of cores) included in the optical fiber core **47** include 2, 4, 8, and 12. In FIG. **42**A, the 12-core constitution is simplified and only 6 cores are shown. The optical fiber cord in this embodiment has a constitution in which a single optical fiber tape core is received in a sheath, but is not particular to this constitution. For example, a constitution in which a plurality of single-core optical fiber cores are received in a single sheath, a constitution in which a plurality of optical fiber tape cores are received in a single sheath, and a constitution in which one or more optical fiber tape cores and signal-core optical fiber cores are received in a single sheath can be employed as the constitution of the external optical fiber.

Since an alignment mechanism such as a V groove is not necessary for a pair of reinforcing members **51** and **54** to be described later, the number of cores of the optical fiber which are held between a pair of reinforcing members **51** and **54** is not specified depending on the structure of a pair of reinforcing members **51** and **54**, as long as it can be received within the width range of adhesion layers **53** and **56**. The specification of a pair of reinforcing members **51** and **54** applied to optical fiber connectors with different numbers of cores such as 2 cores, 4 cores, 8 cores, and 12 cores can be used in common. That is, by changing only the ferrule to a ferrule having a suitable number of cores, an optical fiber connector having a different number of cores can be constructed, thereby contributing to a decrease in cost.

The sheath **48** is formed of a resin such as polyethylene and preferably has flexibility. A plurality of tensile fibers **49** extend along the length direction of the optical fiber and functions as a tensile member accepting a tensile force (tension) to the optical transmission medium. The fiber material used for the tensile fiber **49** is not particularly limited as long as it can provide a necessary tensile strength, and examples thereof include aramid fiber, glass fiber, and carbon fiber.

The tensile member or the sheath is not essential to the invention. For example, an optical fiber core or an optical fiber tape core not having a sheath may be used as the external optical fiber. In some structures of an optical fiber cable or the like, metal wires such as steel wires or various wires such as fiber-reinforced plastic (FRP) may be used as the tensile member.

The inserted optical fiber **40** is an optical fiber of which one end portion **42** is fixed to the ferrule **280** and of which the other end portion **43** protrudes (extends) backward from the ferrule **280**. In this embodiment, the inserted optical fiber **40** includes a multi-core optical fiber core **41** which is an optical fiber tape core, and the resin coating of the optical fiber core **41** and the resin coating of the optical fiber wires are removed in one end portion **42** and the other end portion **43** of the optical fiber core **41** so as to separate into a plurality of bare optical fibers (parts of cores and clads).

The optical fiber used as the inserted optical fiber **40** is not limited to the multi-core optical fiber, but a structure in which one or more short single-core optical fibers are inserted into a single ferrule, a structure in which one or more optical fiber tape cores and single-core optical fiber cores are received in a single ferrule, or the like may be employed.

As shown in FIG. **44**, the other end portion **43** of the inserted optical fiber **40** and the front end portion **46** of the external optical fiber **45** correspond to each other in a one-to-one manner and are fusion-spliced to each other. As shown in FIG. **43**, the fusion-spliced portion **44** of the other end portion **43** of the inserted optical fiber **40** and the front end portion **46** of the external optical fiber **45** is pinched between a pair of reinforcing members **51** and **54** to reinforce the fusion-spliced portion. The ferrule **280** around the inserted optical fiber **40** is not shown in FIG. **44**, but one end portion **42** of the inserted optical fiber **40** is preferably fixed into an optical fiber insertion hole **283** (fiber hole) of the ferrule **280** before the fusion-splice to the external optical fiber **45**.

As shown in FIG. **43**, the ferrule **280** includes a front end face (joint end face) **281** butt-jointed to a ferrule (not shown) of another optical fiber connector, a rear end face **282** which is the opposite end face of the joint end face **281**, optical fiber insertion holes (micro holes) **283** opened in the joint end face **281**, and a boot-receiving hole **287** opened in the rear end face **282**. The ferrule **280** can be formed, for example, as an integrated molded product formed of plastic. The joint end face **281** of the ferrule **280** may be a vertical face perpendicular to the central axis (substantially matched with the optical axis of the optical fiber **42**) of the optical fiber insertion holes **283**, or may be an inclined face inclined in a predetermined direction corresponding to a ferrule of another optical fiber connector.

The optical fiber insertion holes **283** are formed in the same number as the number of optical fibers in one end portion **42** of the inserted optical fiber **40**. For example, a method of injecting an adhesive into the optical fiber insertion holes **283** to adhere to the bare optical fibers can be simply used as the method of fixing the bare optical fibers which are one end portion **42** of the inserted optical fiber **40** to the ferrule **280**. The optical fiber insertion holes **283** are connected to the boot-receiving hole **287**. A ferrule boot **288** is attached around the optical fiber core **41** and is received in the boot-receiving hole **287**. The ferrule boot **288** is preferably formed of a flexible material such as rubber or elastomer, but the ferrule boot **288** may be formed of a material such as a resin or a metal having low flexibility.

Examples of the number of optical fiber insertion holes **283** (the number of cores) formed in the ferrule **12** include 2, 4, 8, and 12. In FIG. **42**A, the structure of **280** cores is simplified and only 6 cores are shown. In the optical fiber connector **100** according to this embodiment, a single-core ferrule may be used as the ferrule **280**.

The optical fiber insertion holes **283** on the joint end face **281** of the multi-core ferrule **280** are arranged in a line to match with the arrangement of optical fibers pinched between the reinforcing members **51** and **54** to be described later. The invention is not limited to the constitution in which the arrangement of optical fibers in the ferrule **280** is set to be the same as the arrangement of optical fibers in the splice reinforcing portion **50**, but the arrangement of optical fibers separated for each core between the ferrule **280** and the splice reinforcing portion **50** may be changed.

For the purpose of alignment when coupling the ferrule **280** to another ferrule of another optical fiber connector, a guide pin **285** passing through the joint end face **281** and the rear end face **282** may be provided (a pin fitting positioning type). The tip of the guide pin **285** protrudes from the joint end face **281** and the guide pin is inserted into a guide pin insertion hole (not shown) formed in the ferrule of another optical fiber connector to suppress the shaking in the direction along the joint end face **281** (such as the vertical direction in FIG. **43**A, the vertical direction in FIG. **43**B, or an inclined direction obtained by combining the directions). When a guide pin is provided to a ferrule of another optical fiber connector, a guide pine insertion hole is provided to the ferrule **280**. A hole formed as a trace of pulling out the guide pin **285** from the ferrule **280** may be used as the guide pin insertion hole **285***a*. Alternatively, the ferrule **280** having a guide pin insertion hole formed thereon instead of the guide pin **285** may be used at the first time.

Preferably, the guide pin **285** can be attached and detached by the insertion and the pulling-out into and from the guide pin insertion hole **285***a*, since it can be easily determined on the splicing site with which of the optical fiber connector **100** and another optical fiber connector to provide the guide pin. For example, when the jointed state of the optical fiber connector **100** and another optical fiber connector is released, a pin clamp **19** is disposed on the rear end face **282** of the ferrule **280** so as to prevent the guide pin **285** from being unintentionally pulled out. In this embodiment shown in FIG. **42**, the pin clamp **19** fills a gap between the ferrule **280** and the splice reinforcing portion **50** and includes a spring seat **20** for accepting an impelling force (pressing force based on elasticity) from a ferrule spring **24**. Accordingly, even when the guide pin **285** is not installed in the ferrule **280**, the pin clamp **19** is attached to the ferrule **280**. The pin clamp **19** can be inserted into and fixed to the ferrule **280** by, for example, irregularity or the like (not shown).

The guide pin **285** may be fixed to the guide pin insertion hole **285***a* (for example, by adhesion or embedment through insert molding) for use.

An example of the reinforcing members **51** and **54** (pinch members) used in this embodiment is shown in FIGS. **45** to **48**. The first reinforcing member **51** used in the upper side of FIG. **43**B is shown in FIG. **45**A and the second reinforcing member **54** used in the lower side of FIG. **43**B is shown in FIG. **45**B. In this embodiment, the reinforcing members **51** and **54** includes reinforcing member bodies **52** and **55** (pinch member bodies) formed of a hard material such as a resin or a metal and adhesion layers **53** and **56** disposed on the inner surfaces coming in contact with the other end portion **43** of the inserted optical fiber **40** and the front end portion **46** of the external optical fiber **45**, respectively.

As shown in FIG. **49**, the adhesion layers **53** and **56** are depressed at the position where the inserted optical fiber and the external optical fiber (which are comprehensively represented by the optical fibers F in FIG. **49**) come in contact with each other to closely adhere to the outer circumferential surfaces of the optical fibers F in the vicinity of the fusion-spliced portion **44**. Accordingly, a mechanism such as a V groove or a U groove used to align the optical fibers is not necessary to form in the inner surfaces of the reinforcing members. In this embodiment, since the other end portion **43** of the inserted optical fiber **40** and the front end portion **46** of the external optical fiber **45** are fusion-spliced in advance, the splice loss is small and the loss is not increased due to the axial misalignment (misalignment of the optical axes) of both optical fibers or the separation of the end faces.

In the case of the groove-like mechanism such as a V groove or a U groove, when the outer diameter in the vicinity of the fusion-spliced portion **44** is greater than the original outer diameter of the optical fibers (before the fusion splice), an excessive pressing force acts on the fusion-spliced portion **44**, thereby shortening the lifetime. On the other hand, when the outer diameter in the vicinity of the fusion-spliced portion **44** is smaller, the positioning of the optical fibers is not stabilized and the positions of the optical fibers may be misaligned in the lateral direction in the grooved mechanism. On the contrary, when the adhesion layers **53** and **56** have deformability following the outer circumferential surface of the optical fibers F, the positioning of the optical fibers F is stabilized, thereby suppressing the warp of the optical fibers F with the lapse of time or the increase in loss.

In this embodiment, as shown in FIG. **49**, at the position where the optical fibers F in the fusion-spliced portion **44** are pinched between a pair of reinforcing members **51** and **54**, the adhesion layers **53** and **56** of the pair of reinforcing members **51** and **54** closely adhere to each other on both sides (on both sides in the width direction perpendicular to the length direction) of the optical fibers F. Accordingly, it is possible to suppress the warp of the optical fibers F with the lapse of time or the increase in loss. Since there is no gap between the opposed adhesion layers **53** and **56**, it is possible to prevent the permeation of moisture or the like which may adversely influence the lifetime of bare optical fibers (particularly, in the case of quartz optical fibers). When an opaque material is used for the adhesion layers **53** and **56**, it is possible to prevent the leakage of light (leaking light) from the gap between the adhesion layers **53** and **56**.

The adhesion layers **53** and **56** are preferably formed of a flexible elastic material such as rubber or elastomer. Accordingly, when the optical fibers F are pinched between the adhesion layers **53** and **56** with a pressing force, the adhesion layers are depressed at the position where they come in contact with the optical fibers F and thus more closely adhere to the outer circumferential surfaces of the optical fibers F with the elastic force of the adhesion layers **53** and **56**. The elastic force of the adhesion layers **53** and **56** has such a magnitude that the original flat surface is restored, when the pressing force is released after the depression.

When a foamed material is used for the adhesion layers **53** and **56**, it is preferable that bubbles be small and the bubbles be independent of each other (the bubbles be not connected). An adhesive (pressure-sensitive adhesive) may be used as the adhesion layers **53** and **56**, but it is preferable that the adhesion layers **53** and **56** be non-adhesive (the adhesive force is small or zero to such an extent that the bare optical fibers **43** and **46** can be easily detached after the temporary disposing) so as to dispose the bare optical fibers **43** and **46** again after temporarily disposing them. When the adhesive force of the surfaces of the adhesion layers **53** and **56** is weak, it is difficult to cause the adhesion layers **53** and **56** to closely adhere to the bare optical fibers **43** and **46**. Accordingly, it is preferable that the positional relationship between the first reinforcing member **51** (the first pinch member) and the second reinforcing member **54** (the second pinch member) be fixed to maintain appropriate pressing forces from both sides.

As shown in FIGS. **45** to **47**, a pair of reinforcing members **51** and **54** includes protuberance portions **61** and recessed portions **62**, respectively, engaging with each other on both sides in the width direction (the direction perpendicular to the paper surface of FIGS. **46** and **47**) which is the direction perpendicular to the length direction of the inserted optical fiber **40** and the external optical fiber **45**. By causing the protuberance portions (engaging protuberance portions) **61** and the recessed portions (engaging recessed portions) **62** to engage with each other, the state where the adhesion layers **53** and **56** of the pair of reinforcing members **51** and **54** closely adhere to each other is maintained. Accordingly, even when the adhesion therebetween is not maintained with only the adhesive force between the adhesion layers **53** and **56**, it is possible to cause the adhesion layers **53** and **56** to satisfactorily closely adhere to each other and thus to prevent the first reinforcing member **51** and the second reinforcing member **54** from being separated from each other.

In this embodiment, as shown in FIG. **45**B, the body **55** of the second reinforcing member **54** includes a bottom portion **57** and side wall portions **58** and **58** formed on both sides in the width direction thereof and the engaging recessed portion **62** is a through-hole formed in the side wall portions **58**. Accordingly, it is possible to easily confirm the engagement state of the engaging recessed portions **61** from the outside with the naked eye or a magnifier. From the viewpoint of the incorporation of the reinforcing members **51** and **54**, only the inner surfaces of the side wall portions **58** to form holes (blind holes) not penetrating the outer surface as the engaging recessed portions. Instead of forming the engaging protuberance portions in the first reinforcing member and forming the engaging recessed portions in the second reinforcing member **54**, the engaging protuberance portions may be formed in the second reinforcing member and the engaging recessed portions may be formed in the first reinforcing member **54**. Various combinations such as a combination of alternately forming the engaging protuberance portion and the engaging recessed portion in the first reinforcing member and alternately forming the engaging recessed portion and the engaging protuberance portion in the second reinforcing member so as to be complementary thereto may be employed.

The side wall portion **58** of the second reinforcing member **54** is divided into a plurality of parts (tongue-shaped parts) by cutouts **59** and one or less engaging recessed portions **62** are disposed on one side. Accordingly, as shown in FIG. **48**, when the first reinforcing member **51** is interposed between the pair of side wall portions **58** opposed to each other in the width direction, the side wall portions **58** having the engaging recessed portions **62** can be independently opened and closed. Even when a set of engaging portions is loosened, the other engaging portions are not loosened therewith. In the front end portions (the upper side of FIG. **48**) of the side wall portions **58** protruding from the bottom wall portion **57**, an inclined surface **58***a* is formed on the inner surface side of the side wall portion **58**. Accordingly, it is possible to easily interpose the first reinforcing member **51** between the pair of side walls **58** opposed to each other in the width direction. When the engaging protuberance portions **61** and the engaging recessed portions **62** are disengaged from each other after the pair of reinforcing members **51** and **54** are combined, a tool may be inserted into the clearance between the inclined surface **58***a* of the side wall portion **58** and the first reinforcing member body **52** to easily push and open the side wall portion **58** to the outside in the width direction.

The adhesion layers **53** and **56** in this embodiment include swelled portions **53***a* and **56***a* of which the surface is raised higher in the vicinity of the fusion-spliced portion **44** and thus the pressing force can be kept higher between the swelled portions **53***a* and **56***a*. Alleviated portions **53***b* and **56***b* which are lower in height than the swelled portions **53***a* and **56***a* and which are alleviated in pressing force are disposed on both sides of the swelled portions **53***a* and **56***a* (on both sides in the length direction of the bare optical fibers **43** and **46**). Examples of a method of forming the swelled portions **53***a* and **56***a* include a method of forming protrusions in the reinforcing member bodies **52** and **55** in the back of the adhesion layers **53** and **56** and a method of partially increasing the thicknesses of the adhesion layers **53** and **56**.

The sets of engaging portions including the sets of the engaging protuberance portions **61** and the engaging recessed portions **62** are disposed in the length direction of the optical fibers. Specifically, one set (or two or more sets) is disposed at the position of the swelled portions **53***a* and **56***a*, one set (or two or more sets) is disposed at the position of the alleviated portions **53***b* and **56***b* on the side of the inserted optical fiber **40**, and one set (or two or more sets) is disposed at the position of the alleviated portions **53***b* and **56***b* on the side of the external optical fiber **45**. Accordingly, the pressing force applied to the fusion-spliced portion **44** from the swelled portions **53***a* and **56***a* can be adjusted by adjusting the positional relationship of the engaging portions in the swelled portions **53***a* and **56***a*. Even when the pressing force of the swelled portions **53***a* and **56***a* is excessively strong and the engaging portions are loosened due to the repulsive force between the swelled portions **53***a* and **56***a*, the engaging portions in the alleviated portions **53***b* and **56***b* are not loosened well, thereby preventing the first reinforcing member **51** and the second reinforcing member **54** from being separated from each other.

As shown in FIG. **43**B, a ferrule boot **288** covering the part of the inserted optical fiber **40** extending from the ferrule **280** is attached to the ferrule **280**. The pair of reinforcing members **51** and **54** (specifically, the bodies **52** and **55** thereof) include protrusions serving as boot clamping portions **52***a* and **55***a* at ends close to the ferrule **280** and the ferrule boot **288** is clamped between the boot clamping portions **52***a* and **55***a*. Accordingly, both ends of the ferrule boot **288** is tightly held between the ferrule **280** and the pair of reinforcing members **51** and **54**, thereby satisfactorily preventing the warp or damage of the inserted optical fiber **40**.

The method of assembling the optical fiber connector **100** according to this embodiment includes a step of fusion-splicing the other end portion **43** of the inserted optical fiber **40**, of which one end portion **42** is fixed to the ferrule **280** and of which the other end portion **43** protrudes from the ferrule **280**, to the front end portion **46** of the external optical fiber **45** and then pinching the fusion-spliced portion **44** between the pair of reinforcing members **51** and **54** to integrate them into a body. Accordingly, the adhesion layers **53** and **56** disposed on the inner surfaces of the reinforcing members **51** and **54** can be caused to closely adhere to the outer circumferential surfaces of the bare optical fibers **43** and **46** in the fusion-spliced portion **44**.

As shown in FIG. **50**, a structure in which the other end portion **43** of the inserted optical fiber **40** protruding from the ferrule **280** is fusion-spliced to the front end portion **46** of the external optical fiber **45** is prepared. The fusion-spliced portion **44** is pinched between a pair of reinforcing members **51** and **54** to integrate them into a body.

In this embodiment, a ferrule to which the guide pin **285**, the ferrule boot **288**, the pin clamp **19**, and the internal optical fiber **40** are attached in advance is used as the ferrule **280** and the other end portion **43** of the inserted optical fiber **40** has only to be fusion-spliced to the front end portion **46** of the external optical fiber **45** on the splicing site. When the pin clamp **19** can be attached and detached after assembling the splice reinforcing portion **50**, the assembling work may be performed in a state where the guide pin **285** or the pin clamp **19** is detached from the ferrule **280**.

By assembling the housing H or the like receiving the ferrule **280** and the splice reinforcing portion **50** after assembling the splice reinforcing portion **50** to the rear side of the ferrule **280**, the optical fiber connector **100** shown in FIG. **31** can be completed.

The optical fiber connector **100** described in this embodiment is a multi-core optical fiber connector and the example shown in the drawings is an MPO type optical fiber connector (F13 type multi-core optical fiber connector defined in the JIS C5982, MPO: Multi-fiber Push On). The optical fiber connector applicable to the invention is not limited to the single-core type or the multi-core type.

The housing H of the optical fiber connector **100** includes a sleeve-like (tubular) plug frame **21** and a sleeve-like (tubular) stop ring **30** attached to the rear end of the plug frame **21**. The side surface of the ferrule **280** is held from the surrounding by the front opening **22** of the plug frame **21**. An engaging claw **33** which can engage with an engaging window **27** formed in the side wall portion of the plug frame **21** is formed in the outer surface of the stop ring **30** so as to integrate the plug frame **21** and the stop ring **30** into a body. The ferrule spring **24** is disposed around the splice reinforcing portion **50**, the front end of the spring **24** is brought into contact with the spring seat **20** at the rear end of the pin clamp **19**, and the rear end of the spring **24** is brought into contact with the spring seat **31** at the front end of the stop ring **30**.

When the joint end face **281** of the ferrule **280** is jointed to a ferrule of another optical fiber connector, the ferrule **280** is guided in the opening **22** and pushed backward to contract the ferrule spring **24**, an appropriate force acts between the joint end face **281** of the ferrule **280** and a joint end face of a ferrule of another optical fiber connector, thereby bringing the joint end faces into close contact with each other. When the joint between the ferrule **280** and the ferrule of another optical fiber connector is released, the ferrule spring **24** is stretched and the ferrule **280** moves in the opening **22** and is restored to the original position.

An engaging portion **23** used for the MPO type connector plug to engage with an engaging claw (not shown) of an MPO type connector adaptor or a receptacle is disposed on both sides (both side in the vertical direction in FIG. **42**A) in the width direction of the plug frame **21**. A coupling **25** is disposed on the outer circumference of the plug frame **21**, and a pair of coupling springs **26** and **26** is received between the outer circumferential surface of the plug frame **21** and the inner circumferential surface of the coupling **25**. Accordingly, the coupling **25** can move forward and backward relative to the plug frame **21** with the stretching and contracting of the coupling springs **26** and **26**. The engaging portion **23** or the coupling **25** has the same constitution as defined in the JIS or the like as the MPO type connector plug.

When the invention is applied to different types of optical fiber connectors, the constituents required for the joint (connector joint) of the optical fiber connectors are installed in the ferrule or the housing.

In the optical fiber connector **100** shown in FIG. **42**, a cap **290** is provided to protect the front end portion of the ferrule **280** of the optical fiber connector plug or the like. The cap **290** is detached in use (at the time of jointing to another optical fiber connector).

The basic structure of the cap **290** is the same as cap **150** described in the third embodiment.

That is, as shown in FIGS. **42**A and **42**B and FIGS. **51**A to **51**C, the cap **290** has a constitution in which a hooking protrusion **292** (tensile member detaining portion) used to detain the tensile fiber **49** (also referred to as a tensile fiber set) protrudes from the outer surface of a cap body **291** of a bottomed cylinder which is detachably externally inserted onto the front end portion (the front end portion of the plug frame **21**) of the housing H of the optical fiber connector **100**.

The cap body **291** of the cap **290** shown in the drawings includes a bottomed cylinder of which one end in the axis direction of a tubular body portion **291***a* which can be externally inserted onto the front end portion of the housing H of the optical fiber connector **100** is blocked by an end wall **291***b*, and is externally inserted onto the front end portion of the housing H, that is, the portion of the housing H (specifically, the plug frame **21**) protruding more forward from the coupling **25** so as to be attached thereto and detached therefrom.

The hooking protrusion **292** protrudes to be inclined about the axis line of the tubular body portion **292** so that as it goes from the tubular body portion **292** of the cap body **291** to the front end blocked by the end wall **291***b* of the cap body **291**, the distance from the outer circumferential surface of the tubular body portion **292** increases.

In the cap **290** shown in the drawings, the hooking protrusions **292** protrude from both sides with the axis line of the tubular body portion **292** of the cap body **291** interposed therebetween.

The cap **290** is a plastic molded product and can be produced at a low cost.

A key groove **291***c* fitted to a key **21***a* formed on one of the side surfaces of the plug frame **21** is formed in the inner surface of the cap **291**. The key **21***a* of the plug frame **21** is conventionally installed to prevent the vertically-reverse use (of the top and bottom in FIG. **42**B) of an optical fiber connector plug, and the key groove **291***c* of the cap **290** is installed on both sides in the vertical direction. Accordingly, it is possible to attach the cap **290** to the optical fiber connector **100** without distinguishing the upside and downside of the cap **290**.

A through-hole **32** passing in the front-rear direction (the lateral direction in FIG. **42**) along the length direction of the optical fiber is formed in the stop ring **30**. The cross-sectional shape (the sectional shape in the plane perpendicular to the length direction of the optical fiber) of the through-hole **32** has at least a size which can receive the shape of the cross-sectional shape of the splice reinforcing portion **50**. Accordingly, when the stop ring **30** is pushed in toward the plug frame **21** from the rear side of the splice reinforcing portion **50** in a state where the ferrule **280** is inserted into the opening **22** of the plug frame **21**, the stop ring **30** is prevented from interfering with the splice reinforcing portion **50** (hindering the push thereof). When the stop ring **30** is pushed in toward the plug frame **21** from the rear side of the splice reinforcing portion **50**, the engaging claw **33** is drawn into the splice reinforcing portion **50** just before the engaging claw **33** reaches the engaging window **27**. Accordingly, on the back surface side of the engaging claw **33**, a groove **32***a* is formed in the inner surface of the through-hole **32**, thereby avoiding the interference of the splice reinforcing portion **50** with the back surface of the engaging claw **33**.

An external screw **34** (a screw portion, a male screw) is formed on the outer circumferential surface of the rear end portion of the stop ring **30**. An internal screw **36** (a female screw) formed on the inner circumferential surface of the screw ring **35** (a screwed ring member) can be fastened to the external screw **34**. The front end portion of the tensile fiber **49** of the external optical fiber **45** can be pinched and fixed between the external screw **34** and the internal screw **36**. The screw ring **35** includes an opening **37** at the rear end thereof, and a part of the tensile fiber **49** of the external optical fiber **45** and the optical fiber core **47** is inserted into the opening **37**. The cross-sectional shape (the sectional shape in the plane perpendicular to the length direction of the optical fiber) of the opening **37** preferably has a certain opening size so as to avoid the contact of the tensile fiber **49** with the splice reinforcing portion **50**.

A boot **65** for an external optical fiber for protecting the external optical fiber **45** is attached to the outer circumferential surface of the screw ring **35**. The boot **65** is generally formed of a flexible material such as rubber or elastomer. In this embodiment, a protective tube **66** is attached around the sheath **48** of the external optical fiber **45** and an annular locking portion **67** having a large diameter at the front end portion of the tube **66** is inserted into the boot **65**.

The sequence of assembling the housing or the like is not particularly limited, but the following sequence can be employed as an example.

As an advance preparation before the fusion splice, the ferrule spring **24**, the stop ring **30**, the screw ring **35**, the external optical fiber boot **65**, and the protective tube **66** are made to pass around the external optical fiber **45**. These components are preferably arranged on the rear side (the right side in FIG. **42**) so as not to interfere with the fusion splice.

As described above, the bare optical fibers **43** and **46** are fusion-spliced, the splice reinforcing portion **50** is assembled thereto, the plug frame **21** is attached thereto from the front side (the left side in FIG. **42**) of the ferrule **280** to dispose the ferrule **280** in the opening **22** of the plug frame **21**, the stop ring **30** is pushed into the plug frame **21** to cause the engaging claw **33** to engage with the engaging window **27**, and the ferrule spring **24** is received along with the ferrule **280** and the splice reinforcing portion **50**. The cap **290** and the coupling **25** may be attached to the plug frame **21** in advance or may be attached thereto after the cap **290** and the coupling **25** are attached to the stop ring **30**.

As shown in FIG. **52**, the front end portion of the tensile fiber **49** passes through the external screw **34** of the stop ring **30** and is hooked on and detained in the hooking protrusion **292** of the cap **290** attached to the plug frame **21**, tension is applied to the tensile fiber **49**, and the internal screw **36** of the screw ring **35** is fastened to the external screw **34** in this state to fix the front end portion of the tensile fiber **49**.

When the front end portion of the tensile fiber **49** fixed to the stop ring **30** extends over the outer circumference of the plug frame **21**, the tensile fiber is cut out if necessary. The boot **65** is externally inserted onto and attached to the screw ring **35** to receive the rear end of the stop ring **30**. The optical fiber connector **100** shown in FIG. **42** can be assembled through this sequence.

It is possible to obtain a cap-attached optical connector **100**A having a constitution in which the cap **290** is attached to the front end portion of the optical fiber connector **100** at the same time as completing the assembling of the optical fiber connector **100**.

The invention is not limited to the above-mentioned embodiments, but may be appropriately modified in design without departing the concept of the invention.

(1) A swaging fixing method using a swage ring may be employed as the method of fixing the tensile fiber to the housing.

For example, as shown in FIGS. **53**A and **53**B, a constitution may be employed in which the tensile fiber sets **2***h* can be fixed to the housing **214**A by employing a housing **214**A which is formed in a sleeve shape receiving a ferrule and which has a swage ring attachment portion **214***c* in which a swage ring **216**A is fixed to the outer circumference thereof, detaining the tensile fiber sets **2***h* extending forward from the terminal of the optical transmission medium (the optical fiber cord **2** in FIGS. **53**A and **53**B) through the vicinity of the swage ring attachment portion **214***c* in the hooking protrusion **152** of the cap **150**, and fixing the swage ring **216**A to the swage ring attachment portion **214***c* by swaging in this state. A protrusion for partially deforming the swage ring **216**A at the time of swaging and enhancing the fixing force of the tensile fibers is formed to protrude from the outer circumference of the swage ring attachment portion **214***c*.

Here, the swaging fixation requires a swaging tool for swaging a swage ring, but the fixation of the tensile fiber based on the screwing of a screwed ring member can be easily embodied by only rotationally operating and screwing the screwed ring member to the screw portion, which is advantageous in that no tool is necessary for the fixation of the tensile fiber.

(2) The method of optically splicing an optical fiber drawn out from the terminal of an optical transmission medium to an inserted optical fiber inserted into and fixed to a ferrule is not particularly limited. For example, a mechanical splicing method of clamping and fixing a pair of optical fibers butt-jointed to each other and maintaining the butt-jointed state may be employed.

(3) The tensile member detaining portion of a cap is not limited to the hooking protrusion, as long as it can detain a tensile fiber.

For example, like the cap **300** shown in FIG. **54**, a constitution for pinching and fixing a tensile fiber between the outer surface of a cap body **310** and a pressing plate **330** (the tensile member detaining portion) rotatably disposed on both sides of the cap body **310** with a hinge portion **320** interpose therebetween may be employed. The pressing plate **330** of the cap **300** shown in FIG. **54** can maintain the state where it is closed with respect to the outer surface of the cap body **310** by causing an engaging recessed portion **331** formed in the pressing plate **330** to engage with an engaging claw **311** protruding from the cap body **310**

FIGS. **55** to **60** show a specific example of the assembling tool shown in FIGS. **8** to **13**.

FIG. **55** is a perspective view of the assembling tool **370**. FIG. **56** is a plan view of the assembling tool **370**. FIG. **57** is a side view of the assembling tool **370**. FIG. **58** is a longitudinal sectional view of the assembling tool **370** and is a sectional view taken along line **A1**-**A1** of FIG. **56**. FIG. **59** is a partially-enlarged plan view of the assembling tool **370**. FIG. **60** is a cross-sectional view of the assembling tool **370** and is a sectional view taken along line **A2**-**A2** of FIG. **56**.

The assembling tool **370** is used to assemble the splice reinforcing portion **50** and includes a base **376**, a reinforcing member holding portion **371** holding the second reinforcing member **54** at a predetermined position, a core holding portion **372** holding a part of the optical fiber core **47** of the external optical fiber **45**, a bearing supporting portion **373** having a bearing portion **374** rotatably holding the shaft portion **60** of the first reinforcing member **51**, and a pressing cover **375** pressing the part of the optical fiber core **47** of the external optical fiber **45** on the core holding portion **372**.

Hereinafter, the right side in FIG. **56** may be referred to as a front side and the opposite side (the left side in FIG. **56**) thereof may be referred to as a rear side. The left-right direction in FIG. **56** may be referred to as a front-rear direction. In the example shown in the drawings, the bare optical fibers **43** and **46** and the external optical fiber **45** are arranged in the front-rear direction (see FIG. **62** and the like).

As shown in FIGS. **55**, **56**, and **59**, the reinforcing member holding portion **371** protrudes upward from the top surface of the base **376** and a holding recessed portion **381** holding the second reinforcing member **54** is formed on the top surface thereof. The holding recessed portion **381** is formed to extend along the front-rear direction (the left-right direction in FIG. **56**) and can position the second reinforcing member **54** with a posture parallel to the front-rear direction.

As shown in FIG. **59**, in this embodiment, a positioning protuberance portion **381***a* protrudes inward from both edges of the holding recessed portion **381** and the second reinforcing member **54** can be fitted between the positioning protuberance portions **381***a* and **381***a* at both edges.

As shown in FIGS. **55** and **56**, the core holding portion **372** protrudes upward from the top surface of the base **376** and the optical fiber core **47** of the external optical fiber **45** can be placed on a flat top surface **372***a* thereof (see FIG. **62** and the like). A pair of regulating recessed portions **383** regulating the movement in the width direction of the external optical fiber **45** is formed on the top surface **372***a*. By interposing the external optical fiber **45** between the regulating protuberance portions **383**, it is possible to determine the position in the width direction of the external optical fiber **45**.

An insertion recessed portion **384** into which a latch portion **382** of the pressing cover **375** is inserted is formed on the top surface **372***a* of the core holding portion **372**.

As shown in FIGS. **55**, **56**, and **60**, the bearing supporting portion **373** includes a pair of support members **385** and **385** disposed to oppose each other. As shown in FIG. **60**, the support member **385** is formed in an L shape having a side plate portion **386** formed upright on the top surface of the base **376** and a top plate portion **387** extending outward (in the direction in which both move separately from each other) from the upper edge of the side plate portion **386**.

The side plate portion **386** has a plate shape parallel to the front-rear direction and extends upward (the direction perpendicular to the base **376**) from the top surface of the base **376**. The side plate portions **386** and **386** forming a pair are formed to oppose each other. The side plate portions **386** and **386** are preferably elastically bending-deformable so that the bearing portions **374** and **374** are able to come close to each other and to move separately from each other.

By setting the distance between the side plate portions **386** and **386** to be substantially equal to or slightly larger than the width of the optical fiber core **47**, it is possible to position the optical fiber core **47** in the width direction.

As shown in FIGS. **57** and **65**, the lower part of the front edge of the side plate portion **386** is cut out and thus a stepped portion **386***a* is formed at a position slightly higher than the bottom portion of the holding recessed portion **381** in the front edge of the side plate portion **386**.

As shown in FIGS. **55**, **58**, **60**, and **65**, the bearing portion **374** is a hole portion having a substantially circular section formed through at a position close to the front edge of the side plate portion **386**. The bearing portion **374** has an inner diameter substantially equal to or slightly larger than the outer diameter of the shaft portion **60** and can rotatably support the inserted shaft portion **60**. The bearing portions **374** and **374** are formed at the opposed positions of the pair of side plate portions **386** and **386**.

An approach groove **388** is formed in the vertical direction in the inner surface of the side plate portion **386**. The approach groove **388** is a groove formed to guide the shaft portion **60** of the first reinforcing member **51** to the bearing portion **374**, has a width through which the shaft portion **60** can pass, and extends from the upper edge of the side plate portion **386** to the bearing portion **374**.

As shown in FIGS. **60** and **65**, a protuberance portion **388***a* is formed on the bottom portion of the approach groove **388**. Since the protuberance portion **388***a* has such a height to make the upward movement of the shaft portion **60** fitted to the bearing portion **374** difficult, the shaft portion **60** fitted to the bearing portion **374** is not easily detached from the bearing portion **374**.

As shown in FIGS. **55** and **56**, the pressing cover **375** has a long plate shape and a base end portion **375***a* thereof is hinged to one outer edge **372***b* of the core holding portion **372**. By employing the hinge coupling, the pressing cover **375** can be formed in a body with the core holding portion **372**, which is advantageous in manufacturing cost.

As shown in FIG. **62**, the pressing cover **375** rotates about the base end portion **375***a* and overlaps with the top surface **372***a* of the core holding portion **372**, whereby the optical fiber core **47** can be pinched between the top surface **372***a* and the pressing cover.

By inserting the latch portion **382** into the insertion recessed portion **384** in a state where the pressing cover **375** overlaps with the top surface **372***a* of the core holding portion **372** and locking the locking protuberance portion **382***a* to *a* locking recessed portion (not shown) in the insertion recessed portion **384**, it is possible to maintain the state where the optical fiber core **47** is pinched between the pressing cover **375** and the top surface.

By elastically bending the latch portion **382** by external work, it is possible to select the locked state and the unlocked state of the locking protuberance portion **382***a* to and from the locking recessed portion (not shown).

As shown in FIGS. **55** and **56**, a positioning protrusion **391** positioning a holding jig **390** holding the ferrule **12** is formed on the front side of the reinforcing member holding portion **371**. The positioning protrusion **391** can regulate the forward movement of the holding jig **390** received in the reception space **392** between the reinforcing member holding portion **371** and the positioning protrusion.

FIGS. **69** and **70** show a pressing jig **393** pressing the first reinforcing member **51** to the second reinforcing member **54** on the assembling tool **370**. FIG. **69** is a perspective view of the pressing jig **393** as viewed from a side of the top surface and FIG. **70** is a perspective view of the pressing jig **393** as viewed from a side of the bottom surface.

The pressing jig **393** includes a base portion **394** and leg portions **395** and **395** vertically extending downward from both edges of the base portion **394**, and a plurality of pressing protuberance portions **396** pressing the first reinforcing member **51** are formed on the bottom surface of the base portion **394**. In the example shown in the drawings, the pressing protuberance portions **396** are arranged in two lines along both edges of the first reinforcing member **51** and can press the vicinity of the lateral edges of the first reinforcing member **51** at a plurality of points in the length direction of the first reinforcing member **51**.

An example of a method of assembling the splice reinforcing portion **50** using the assembling tool **370** will be described below.

As shown in FIGS. **61** and **66**, the second reinforcing member **54** with a posture arranged along the front-rear direction is held in the holding recessed portion **381** of the reinforcing member holding portion **371**.

As shown in FIG. **59**, the shift in the width direction of the second reinforcing member **54** is prevented by the positioning protuberance portion **381***a*.

As shown in FIG. **66**, since the upward movement of the bottom wall portion **57** can be suppressed by locating the front end portion **57***a* of the bottom wall portion **57** of the second reinforcing member **54** below the stepped portions **386***a* of the side plate portions **386**, the positioning in the vertical direction is possible. By bringing the front end portion of the bottom wall portion **57** or the front end portions of the side wall portions **58** into contact with the side plate portion **386**, it is also possible to regulate the positional shift in the front-rear direction.

As shown in FIG. **62**, a unit (see FIG. **8**) in which the other end portion **43** of the inserted optical fiber **40** protruding from the ferrule **12** is fusion-spliced to the front end portion **46** of the external optical fiber **45** is placed on the assembling tool

370. In the example shown in the drawing, the ferrule **12** is received and held in the holding jig **390**.

The fusion-spliced portion **44** of the bare optical fibers **43** and **46** is placed on the second reinforcing member **54**.

When the holding jig **390** is disposed in the reception space **392** between the reinforcing member holding portion **371** and the positioning protrusion **391**, the movement in the front-rear direction of the holding jig **390** is regulated and thus the positions in the front-rear direction of the bare optical fibers **43** and **46** on the second reinforcing member **54** is determined.

The position in the width direction of the optical fiber core **47** of the external optical fiber **45** is determined by placing the optical fiber core on the top surface **372***a* of the core holding portion **372** and disposing the optical fiber core between a pair of regulating protuberance portions **383** and **383**. The movement in the width direction of the optical fiber core **47** is also regulated by the side plate portions **386** and **386**.

By rotationally moving the pressing cover **375** and interposing the optical fiber core **47** between the pressing cover **375** and the core holding portion **372**, the positional shift of the optical fiber core **47** can be prevented. By inserting the latch portion **382** into the insertion recessed portion **384** and locking the locking protuberance portion **382***a* to the locking recessed portion (not shown) in the insertion recessed portion **384**, the state where the pressing cover **375** pinches the optical fiber core **47** is maintained.

By positioning the optical fiber core **47** by the use of the pressing cover **375**, it is possible to accurately position the optical fiber core **47** and to arrange the optical fiber core **47** in a straight line shape. Accordingly, it is possible to prevent the position shaking of the bare optical fibers **43** and **46** in the splice reinforcing portion **50** due to the bending of the optical fiber core **47** or the like.

As shown in FIGS. **63** and **67**, the shaft portion **60** of the first reinforcing member **51** is caused to approach the approach groove **388** of the side plate portion **386** and is fitted to the bearing portion **374**. The shaft portions **60** and **60** protruding to one side and the other side of the first reinforcing member **51** are inserted into the bearing portions **374** and **374** of the side plate portions **386** and **386**, respectively, and are rotatably supported by the bearing portions **374** and **374**.

As shown in FIGS. **64** and **68**, by rotationally moving the first reinforcing member **51** about the shaft portion **60** fitted to the bearing portion **374**, the fusion-spliced portion **44** and the bare optical fibers **43** and **46** are pinched between a pair of reinforcing members **51** and **54**. As shown in FIG. **68**, when pinching the fusion-spliced portion **44** between a pair of reinforcing members **51** and **54**, the engaging protuberance portions **61** are made to engage with the engaging recessed portions **62**. Accordingly, it is possible to assemble the splice reinforcing portion **50** to the rear side of the ferrule **12**.

As shown in FIG. **71**, when the first reinforcing member **51** is pressed to pinch the fusion-spliced portion **44** and the bare optical fibers **43** and **46** between the reinforcing members **51** and **54**, the pressing jig **393** may be placed on the first reinforcing member **51** and the first reinforcing member **51** may be pressed down through the use of the pressing protuberance portions **396** (see FIG. **70**).

Accordingly, it is possible to press the vicinity of both lateral edges of the first reinforcing member **51** at a plurality of points along the length direction of the first reinforcing member **51** and to satisfactorily cause all the engaging protuberance portions **61** to engage with the engaging recessed portions **62**.

Since all the engaging protuberance portions **61** can be caused to engage with the engaging recessed portions **62** substantially at the same time by the use of the pressing jig **393**, a large sound is generated at the time of causing the engaging protuberance portions **61** to engage with the engaging recessed portions **62**, whereby the completion of the assembling of the splice reinforcing portion **50** can be easily recognized by an operator, thereby improving the workability.

The unit in which the splice reinforcing portion **50** is assembled to the rear side of the ferrule **12** is detached from the assembling tool **370**.

When the upward movement of the shaft portion **60** is regulated by the protuberance portions **388***a*, it is possible to easily detach the shaft portion **60** from the bearing portions **374** by deforming the side plate portions **386** in the direction in which both move separately from each other.

According to the assembling tool **370**, it is possible to accurately position the first reinforcing member **51** with respect to the second reinforcing member **54** and to easily assemble the splice reinforcing portion **50**.

According to the invention, it is possible to treat the assembling tool **370** and the optical fiber connector as an optical fiber connector assembling set. The optical fiber connector assembling set may include a constituent (for example, a pressing jig **393**) other than the assembling tool **370** and the optical fiber connector **10**.

What is claimed is:

1. A pin clamp used for an optical fiber connector comprising a ferrule that has a guide pin insertion hole being formed to receive a positioning guide pin of an opposite optical fiber connector and an optical fiber of which one end portion reaching a joint end face of the ferrule is fixed to the ferrule and of which an other end portion extends from the ferrule,

wherein the pin clamp, which is attachable to a protrusion protruding from the opposite side to the joint end face of the ferrule, being formed to secure the positioning guide pin in the guide pin insertion hole, and being detachable from the ferrule in a direction crossing the guide pin insertion hole,

wherein the pin clamp includes a fitting recessed portion being formed to fit a protruding portion of the positioning guide pin to regulate movement in a length direction of the positioning guide pin,

wherein the fitting recessed portion being formed to receive a protrusion of the guide pin in the direction crossing the guide pin insertion hole,

wherein the ferrule has two guide pin insertion holes including the guide pin insertion hole, the two guide pin insertion holes are formed on both sides with the optical fiber pinched there between,

wherein the pin clamp has a bottom portion and side wall portions formed on both sides thereof and a space surrounded with the bottom portion and the side wall portions on both sides thereof serves as an insertion space of the optical fiber,

wherein the pin clamp has two fitting recessed portions, which are formed in the side wall portions on both sides,

wherein the optical fiber is an inserted optical fiber,

wherein a ferrule boot covering a portion of the inserted optical fiber extending from the ferrule is attached to the portion, and

wherein the pin clamp is formed to insert the ferrule boot into the insertion space.

2. A method of assembling an optical fiber connector comprising a ferrule that has a guide pin insertion hole being formed to receive a positioning guide pin of an opposite optical fiber connector, an optical fiber of which one end portion reaching a joint end face of the ferrule is fixed to the ferrule and of which an other end portion extends from the ferrule, and a pin clamp that is attachable to a protrusion protruding from the opposite side to the joint end face of the ferrule being formed to secure the guide pin in the guide pin insertion hole, and being detachable from the ferrule in a direction crossing the guide pin insertion hole, the pin clamp includes a fitting recessed portion being formed to fit a protruding portion of the guide pin to regulate movement in a length direction of the guide pin, and the fitting recessed portion being formed to receive and put out a protrusion of the guide pin in the direction crossing the guide pin insertion hole, the method comprising the steps of:

splicing the other end portion of the optical fiber to a front end portion of an external optical fiber; and

attaching the pin clamp to the protrusion of the guide pin so that the protrusion of the guide pin is locked to the fitting recessed portion from the direction crossing the guide pin insertion hole,

wherein the ferrule has two guide pin insertion holes including the guide pin insertion hole, the two guide pin insertion holes are formed on both sides with the optical fiber pinched there between,

wherein the pin clamp has a bottom portion and side wall portions formed on both sides thereof and a space surrounded with the bottom portion and the side wall portions on both sides thereof serves as an insertion space of the optical fiber,

wherein the pin clamp has two fitting recessed portions, which are formed in the side wall portions on both sides,

wherein the optical fiber is an inserted optical fiber,

wherein a ferrule boot covering a portion of the inserted optical fiber extending from the ferrule is attached to the portion, and

wherein the pin clamp is formed to insert the ferrule boot into the insertion space.

3. An optical fiber connector comprising:

a ferrule that has a guide pin insertion hole being formed to receive a positioning guide pin of an opposite optical fiber connector;

an optical fiber of which one end portion reaching a joint end face of the ferrule is fixed to the ferrule and of which an other end portion extends from the ferrule; and

a pin clamp that is attachable to a protrusion protruding from the opposite side to the joint end face of the ferrule being formed to secure the positioning guide pin in the guide pin insertion hole, and being detachable from the ferrule in a direction crossing the guide pin insertion hole,

wherein the pin clamp includes a fitting recessed portion being formed to fit a protruding portion of the positioning guide pin to regulate movement in a length direction of the positioning guide pin,

wherein the fitting recessed portion being formed to receive a protrusion of the guide pin in the direction crossing the guide pin insertion hole,

wherein the ferrule has two guide pin insertion holes including the guide pin insertion hole, the two guide pin insertion holes are formed on both sides with the optical fiber pinched there between,

wherein the pin clamp has a bottom portion and side wall portions formed on both sides thereof and a space surrounded with the bottom portion and the side wall portions on both sides thereof serves as an insertion space of the optical fiber, wherein the pin clamp has two fitting recessed portions, which are formed in the side wall portions on both sides,

wherein the optical fiber is an inserted optical fiber,

wherein a ferrule boot covering a portion of the inserted optical fiber extending from the ferrule is attached to the portion, and

wherein the pin clamp is formed to insert the ferrule boot into the insertion space.

4. The optical fiber connector according to claim **3**, wherein the fitting recessed portion is formed to receive the protrusion of the guide pin that has a large-diameter portion and a small-diameter portion having a diameter smaller than that of the large-diameter portion at the tip thereof, and

wherein the fitting recessed portion is locked to the small-diameter portion to regulate movement of the large-diameter portion toward the tip.

5. The optical fiber connector according to claim **3**,

wherein the other end portion of the inserted optical fiber is spliced to an external optical fiber.

6. The optical fiber connector according to claim **3**, wherein a holding protrusion that protrudes to the inside and that regulates movement of the ferrule boot in the insertion space to the outside is formed in the side wall portions of the pin clamp.

7. The optical fiber connector according to claim **4**, wherein

each of the side wall portions includes a plate portion,

the plate portion is vertically upright from a side edge of the bottom portion,

the plate portion includes a fitting recessed portion and an extension,

the fitting recessed portion is configured to regulate movement in a length direction of the positioning guide pin by being fitted into the small-diameter portion of the positioning guide pin,

the extension is formed to extend upward from the further inner position than the fitting recessed portion,

the ferrule boot is configured to be fitted between extensions that are provided at sides of the insertion space, and

a distance between the extensions is substantially the same as a width of the ferrule boot.

8. The optical fiber connector according to claim **7**, wherein

each of the extensions has a holding protrusion that is formed at the inner edge of the extension so as to protrude inward, and

the holding protrusion is configured to regulate an outward movement of the ferrule boot.

* * * * *